REPORT OF THE SCIENTIFIC RESULTS OF THE NORWEGIAN
EXPEDITION TO NOVAYA ZEMLYA 1921. No. 21

O. T. GRØNLIE

CONTRIBUTIONS TO THE QUATERNARY GEOLOGY OF NOVAYA ZEMLYA

WITH XXX PLATES

PRINTED AT THE EXPENSE OF STATENS
FORSKNINGSFOND AV 1919

PUBLISHED BY
VIDENSKAPSSELSKAPET I KRISTIANIA
(THE SOCIETY OF ARTS AND SCIENCES OF KRISTIANIA)

Dr PAUL-L. MERCANTON
PROFESSEUR, LAUSANNE

KRISTIANIA
A. W. BRØGGERS BOKTRYKKERI A/s
1924

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———OOO———

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CONTENTS.

Page

Introduction 5

I. Observations during the Expedition.

1. The West Coast south of Matotchkin Strait.

Goose Land 8
Bessimyannii Fjord and Gribovii Fjord 11

2. Matotchkin Strait and Serebryanka Fjord.

Pomorskaya Bay and Matotchka Valley 16
Serebryanka Fjord 20
The Middle Part of the Strait 24
Belushii Bay 32
The Eastern Entrance of the Strait 37
Summary 39

3. The West Coast between Serebryanka Fjord and Mashigin Fjord.

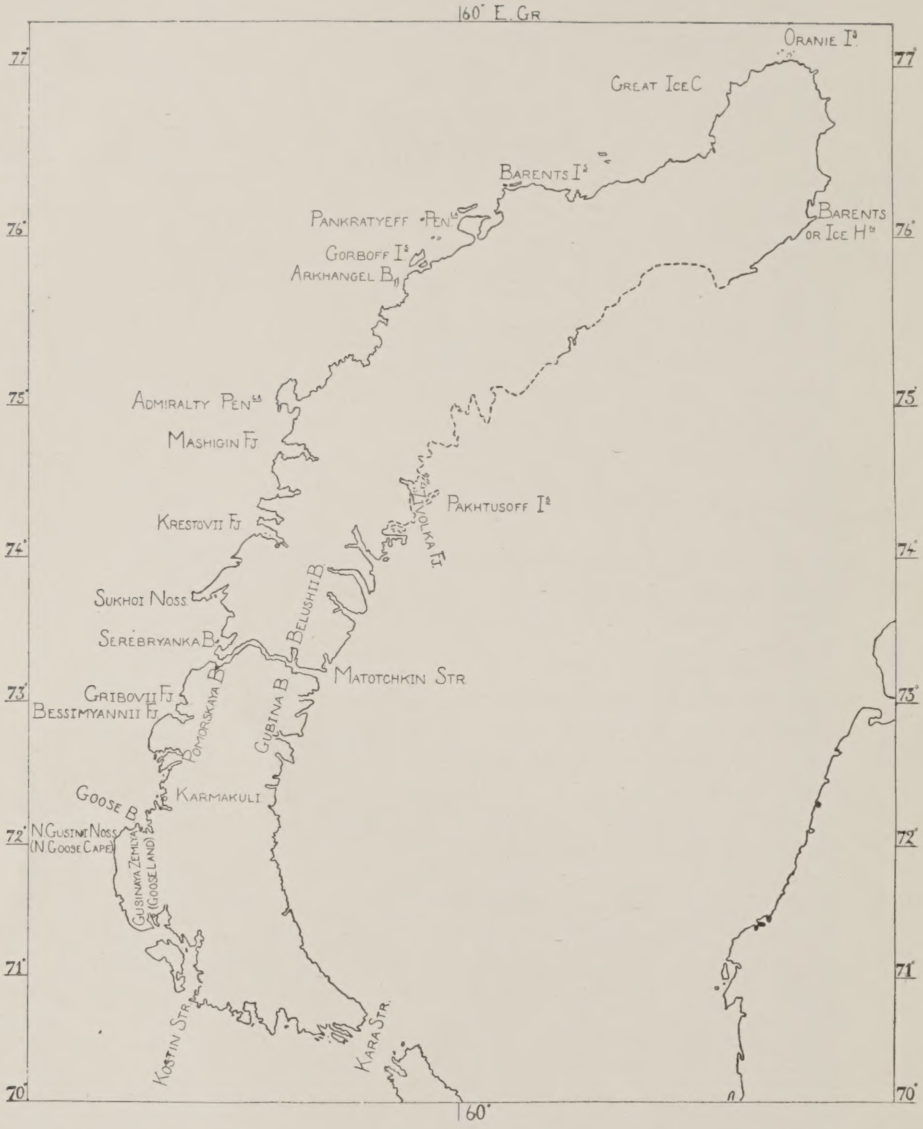
Sukhoi Noss 42
Krestovii Fjord 43

4. Mashigin Fjord.

The Outer Basin 45
Fram Bay and Lynge Glacier 51
Mount Nansen and the South Side of the Middle Basin 51
The North Side of the Middle Basin 54
Lacroix Glacier 55
Blaafjell Glacier 56
The North Side of Blaafjell Basin 58
Boule Glacier 58
From Blaafjell Basin to Zivolka Fjord 59
Summary 62

5. The West Coast between Cape Borisoff and the Pankratyeff Peninsula.

The Strandflat Northeast of Cape Borisoff 64
The Admiralty Peninsula 65
Arkhangel Bay 67
Gorboff Islands 70
The Krestovii or Cross Islands 73
Arkhangel Glacier 74
The Pankratyeff Peninsula 75
Summary 78
II. A General Review of the Landforms 79
III. Novaya Zemlya in Glacial and Postglacial Times 86
IV. An Attempt at correlating the Shore-Lines of Northern Norway, Novaya Zemlya and Spitsbergen 97
V. Some Closing Remarks 113
Literature 117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Gorboff Is.
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Admiralty Penla.
Mashigin Fj.
Krestovii Fj.
Pakhtusoff Is.
Volka Fj.
Sukhoi Noss
Belushii B.
Serebryanka B.
Matotchkin Str
Gribovii Fj.
Bessimyannii Fj.
Pomorskaya B.
Gubtina B.
Goose B.
Karmakuli
N. Gusinii Noss
(N. Goose Cape)
Gusinaya Zemlya
(Goose Land)
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Kara Str.
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75°
74°
73°
72°
71°
70°

INTRODUCTION.

Novaya Zemlya was up to the middle of the sixteenth century only known to Russian sealers and hunters. To the West-Europeans the land was known for the first time through the English expeditions in the last half of the said century: WILLOUGHBY 1553(?), BURROUGH 1556, and PET and JACKMAN 1580.

More important for the knowledge of Novaya Zemlya were the Dutch expeditions 1594 and 1596. During these expeditions WILLEM BARENTZ fixed the site of a number of capes, islands and bays along the west coast and the northern part of the east coast to 76° 15′ north latitude, and he sketched the first usable chart of the coasts visited by him.

During the seventeenth century the coasts of Novaya Zemlya were visited by a good many expeditions chiefly English and Dutch: HUDSON 1608 and 1609, VAN HOORN 1612, BOSMAN 1625, a Danish expedition 1653, the whaler VLAMING 1664, SNOBBEGER 1675, WOOD and FLAWES 1676, and VLAMING a second time 1688. None of these expeditions increased in a degree worth mentioning the knowledge of the land. VLAMING saw from a high mountain the sea penetrating far inland from the west, probably Matotchkin Strait.

After these voyages, most of which having for their aim the discovery of a northeasterly passage to the Pacific, both the English and Dutch gave up sailing in these eastern arctic seas, and it was once more left to the Russian sealers to keep up and enlarge the knowledge of this part of the arctic region. One of these sealers, LOSHKIN, sailed round Novaya Zemlya for the first time about 1760. He found the east coast for the most part low without harbours. There was plenty of driftwood chiefly of larch.

From about 1730 the Russian Government fitted out more expeditions which had it in charge to survey the arctic coasts of the Empire. During the decade 1730—1740 the northern coasts of European Russia were surveyed. In 1768 the islands came in for turn, and an expedition was fitted out and dispatched under the charge of naval lieutenant ROSMYSLOFF for surveying the coasts of Novaya Zemlya and the Kara Sea. ROSMYSLOFF mapped Matotchkin Strait, sounded in several places especially in the western part of the Strait, made observations of the tides etc. He mentions the strandflat for the first time as a low land between the sea shore and the mountains.

According to an old story silver ore should have been seen in Novaya Zemlya, and in order to test the value of this tale an expedition was sent out in the year 1807. LUDLOW who attended the expedition as mineralogist looked for ores in several places, but he found neither silver ore nor other workable ores. He could not acquiesce in the opinion that Novaya Zemlya was a continuation of the Ural mountains as the strike of the rocks did not harmonize. PJOSPELOW who commanded the vessel of the expedition made sketch maps and drew prospects of the coast south of Matotchkin Strait. These maps and prospects proved later on to be of great use to the following explorers.

In the years 1821—1824 lieutenant (later on admiral) LÜTKE undertook by order of the Government four voyages to Novaya Zemlya especially for controlling and improving the charts. He surveyed the west coast from the southermost point to Cape Nassau and fixed the site of most of the capes, bays and fjords, controlled the works of ROSMYSLOFF in Matotchkin Strait etc. (cf. 17, 45 and 67).

The eastern coasts which Lütke on account of ice-hindrances had fallen short of reaching were explored by PAKHTUSSOFF and ZIVOLKA; from the south point to Matotchkin Strait by PAKHTUSSOFF in the summer of 1833, the coast of the north island to 74° 24′ north latitude by ZIVOLKA and PAKHTUSSOFF in the spring and summer of 1835 (cf. 67, pp. 36—43).

The first scientific expedition to Novaya Zemlya was started and conducted by BAER in the year 1837. He visited several places on the west coast of the south island and Matotchtkin Strait where vegetable and animal life was studied, and geological observations were made. ZIVOLKA who accompanied him made geographical observations.

In the years 1838 and 1939 the fjords south of Cape Britwin and the fjords between Sukhoi Noss and Cape Borisoff were explored by ZIVOLKA and MOISSEJEW (69).

During the following 30 years 1840—1870 no expeditions were sent to Novaya Zemlya neither from Russia nor from any other country. Much was yet to be done there. In the year 1867 no rivers, lakes mountains and glaciers were surveyed, and no mapping or charting of the north and east coast had been carried out since the time of Barentz. Most of the inland area was completely unknown (69, p. 47).

About 1870 the runs in the Novaya Zemlya-waters were started afresh. Both the western and eastern coasts were visited by a good many Norwegian sealers: ELLING CARLSEN, the three brothers JOHANNESSEN, TOBIESEN, DØRMA, MACK, ISAKSEN, ULVE, QUALE etc. CARLSEN found the house of BARENTZ in the Iishaven, and E. JOHANNESSEN sailed round the islands a second time. Through the descriptions and observations of these sealers the north coast east of Cape Nassau and the northern part of the east coast became pretty well known (map by PETERMANN). In 1871 the west coast was visited and the eastern part of Matotchkin Strait explored by the ROSENTHAL expedition (20). In 1872 the western part of Matotchkin Strait was explored by the WILCZEK expedition (31), and in the years 1875 and 1876 both the west and the east coast and Matotchkin Strait were surveyed by Swedish expeditions conducted by NORDENSKIÖLD (53). In 1878 and 1879 the west coast and Matotchkin Strait were visited by Dutch expeditions (18), in 1879 also by the MARKHAM expedition (79). In the summer of 1895 a Russian expedition made geological investigations on the west coast from the Goose Land to the middle part of Matotchkin Strait, and in August TCHERNYSHEFF crossed the south island in southeasterly direction from Karmakuly to the east coast at Golizyn Bay (75). At the same time an English expedition under PEARSON undertook ornithological, botanical and geological investigations along the west coast, Matotchkin Strait and the east coast as far as Pakhtussoff Islands and the Ibis Glacier in Zivolka Fjord (56).

In 1901 a Russian expedition in the "Yermak" visited Novaya Zemlya where geological investigations were carried on in Krestovii and Mashigin Fjords, and during the winter 1901—1902 more fjords on the east coast were mapped by BORISOFF. In 1895 and 1902 BREITFUSS investigated the marine fauna. In 1908 the land was visited by a French expedition conducted by CHARLES-BÉNARD. While the leader worked on the southern island, ROUSSANOFF and CANDIOTTI explored the western coasts of the northern island north of Sukhoi Noss and crossed this island in southeasterly direction from Krestovii Fjord to Rosmysloff (Nesnayemi) Fjord on the east coast (5). ROUSSANOFF visited Novaya Zemlya also the next year and undertook geological investigations along Matotchkin Strait and the adjacent parts of the west coast (66).

In the northern part of the west coast, especially at Arkhangel Bay, KROUGLOWSKY in 1910 studied the rocks and measured the lower shore-lines (43), and there and farther to the north the SEDOW expedition 1912—1913 has mapped a greater part of the coast. In the winter 1913 PAVLOW and WIESE, members of this expedition, crossed the inland ice to the east coast. In 1914 CHARLES-BÉNARD once more visited Novaya Zemlya, and in August he went from Kostin Shar to the east coast quite alone (5).

In the summer of 1921 a Russian expedition conducted by WITTENBURG surveyed several places on the west coast and made interesting observations and finds of plant remains from postglacial times (44).

The Norwegian expedition to Novaya Zemlya 1921 under the leadership of professor O. HOLTEDAHL worked along the coasts of the islands for exactly two months as stated in HOLTEDAHL's "Brief Account of the Expedition" (30). The present writer partook in the expedition as geologist for quaternary geology, and the result of my investigations are given below.

The instruments used were a pocket levelling theodolite, two aneroids, Martin Wiig 4, 1908, and 513, 1910, an Ica Camera 9 × 12 and a miners compass. The levelling instrument had been used for many years and had proved to be fit for levellings of shore-lines with sufficiant accuracy. The aneroids were only used on inland excursions and in places where the shore-lines were previously known to a certain extent by levelling in the neighbourhood. 513 proved to be very precise. Its reads were regurlarly compared with the levellings. STRAUMSNES, the master of the "Blaafjell," was a well qualified assistent by levellings, and the photographer LUND developed favourably all plates and films.

By levellings of shore-lines in Norway the Fucus rim is usually used for base. Along the coasts of Novaya Zemlya, however, a Fucus rim is very seldom traceable, and therefore it was necessary to start from the presumed mean level of the sea. As I did not know the former determinations of the range of the tides, I was compelled to find it out myself on the spot. The difference between low and high water was fixed to about 1,20 m. along the south coast and the western part of Matotchkin Strait, to 0,60—0,75 m. in Belushii Bay and to 1,0 m. in Mashigin Fjord and Arkhangel Bay. These observations accord fairly well with determinations prior to mine and are exact enough for their aim (cp. 69, pp. 57—58).

I. OBSERVATIONS DURING THE EXPEDITION.

1. The West Coast south of Matotchkin Strait.

Goose Land.

The Goose Land is a low level or rolling plain between the sea shore and the mountains to the east, about 100 km. long and 10—15 km. wide. It is a lowland similar to the best developed parts of the Norwegian strandflat and must be of the same origin. The western border is generally, or at all events very often, a cliff which faces the sea with a height of from 2 to 10—15 m. To the south the plain seemed to be quite level with a multitude of shallow lakes, of which a great many were past lagoons in which plenty of drift-wood was to be seen.

To the north in the neighbourhood of the Goose Bay, where the lowland was more closely surveyed by the expedition, the rocks that cropped out in cliffs and crags consisted of dark-coloured slates and layers of sandstone with nearly vertical dip. The rock-underground has generally a cover of moraine at the bottom of which, in some places, the slates have been crushed through pressure from the east and in this shape form a base for the moraine. The ground-moraine is often dry and sandy with stones of igneous rocks. At the top the material is fossiliferous as the plain has been covered by the sea after the deposition of the ground-moraine.

Towards the mountains, where the plain ascends to about 70—80 m., the cover of loose material is quite sparse, but the thickness increases in the direction of the coast. Some long and low hills have been considered to be drumlins, and the upper part of the cliffs often consists of a thick layer of moraine. In several places the rock only crops out at the base of the cliff, and there are even places where a rock base was not to be seen.

From the inner border of the strandflat the land surface rises comparatively abruptly to an undulating plateau with a height esteemed to 300—350 m. The mountain wall is very little dissected. According to BÉNARD it is to the south broken by several canyons. To the east of the Goose Bay the edge of the plateau is cut by a flat and broad trough valley, through which the glacier advanced that accumulated the drumlins before mentioned and the ground-moraine cover on the strandflat round Goose Bay after the ice had withdrawn from the rest of the strandflat.

Not far from our anchoring place towards the south-east two raised shore-lines were to be seen along the shores and round the drumlins. The lines were only slightly cut in loose material, and their heights were not easily fixed. By levelling they were found to lie at 10,8 m. and 15,6 m. respectively. Near the cliff at northern Goose Cape was a distinct shore-line 18 m. a. s. l. Along the mountains several higher lines were distinctly marked by horisontal bands of snow that lay in the lines, not yet melted away in the first days of July (Pl. I, fig. 1).

As a detail is to be noted that the land west of our anchorage originally has been an island now connected with the mainland by a flat of loose moraine material washed and levelled by the sea. Along the western border this flat lies 4—5 m. a. s. l., but the height decreases to the east. Several curved lines mark periods in its building (Pl. I, fig. 2). A ditch that runs inwards from the sea shore may have been dug out by sea water washed through an opening in a belt of pack ice along the western edge of the flat. The coast is open against the sea (Pl. I, fig. 3).

On the flat were found shells, drift-wood, a cranium of a polar bear, bones of seals etc. The following shells were gathered:

Mytilus edulis, Lin., 3 valves and 5 fragments of the typical form, length 5 cm.,

Pecten islandicus, Müll., 1 v. 4,9/5,

Cardium grønlandicum, Chemn., 5 fragments,

Astarte borealis, Chemn., 3 v. 34/45, 29/34, 24/28 and two fragments,

Mya truncata, Lin., 1 v. and one fragment,

Fusus fornicatus, Reeve, more specimens.

The shells looked recent and had no doubt been washed ashore by the sea.

A little nearer the anchorage, 20 m. a. s. l., *Saxicava pholadis*, Lin. was found. Four specimens measured had dimensions 18/36, 17/34, 15/30 and 12/22. These shells were found in the sand-mixed marine clay that almost everywhere covers the untouched ground-moraine. This clay has been deposited during a submergence of the land after the recession of the inland ice. How much the Goose Land had been submerged then could not be stated, as there was no opportunity to measure the upper shore-lines which were visible east of the Goose Bay. Along the sea shore where both the rocks and the loose materials are undermined by the seas, these marine sediments often slide and mix with the moraine, which therefore sometimes looks fossiliferous. On that account FEILDEN was of the opinion that all the loose material on the lowland was marine sediments, deposited by drifting ice during the last submergece (56, p. 249).

In the neighbourhood of the anchorage, a little to the west of a cairn, ice-scratching was observed near the sea shore in a dense, dark and sandy shale. This ice-scratched rock surface had probably been protected against weathering by the frozen ground-moraine. Where the rocks lack such a cover, all ice-scratchings have been effaced.

All bays and sounds in the vicinity of the Goose Bay are very shallow with a hard rocky or stony bottom.

Between the Goose Bay and Cape Britwin the land was only seen from the ship under sail to the north. It was, however, easy to see that there was all along the coast a low strandflat — partially dissected by sounds into islands and islets — between the cliff coast and the mountain wall that rises to a plateau with a rounded edge. It is probable that the top of the cliffs consists of moraine and marine sediments in analogy with the cliffs round the Goose Bay. According to TCHERNYSHEFF the valley of Karmakulka River east of Karmakuly is flat and monotonous. This valley which cuts the western part of the plateau for about 30 werst, is therefore an ice-worn trough valley similar to the before mentioned valley east of Goose Bay, the Obtchidei Valley. The height of the inland plateau does not surpass 600 m., and the valleys of the Obtchidei Rivers from the west and Krotov Valley from the east are partly filled by firn ice (75, pp. 138—140). This ice is probably fossil glaciers now dissected by the said rivers and their tributaries.

It is very probable that the last glaciers which reached the sea from the inner plateau, advanced through the valleys just mentioned and the valley of Pukhovii River, and united to a piedmont glacier with unbroken front in Möller Bay beyond the present coast line, while the Goose Land was free from ice and submerged.

Bessimyannii Fjord and Gribovii Fjord.

The peninsula between Pukhovii Bay and Bessimyannii Fjord is a plateau similar to that east of the Goose Land, rising slightly from about 250 to 400 m. To the west it is surrounded by a strandflat that reaches its greatest breadth at Cape Britwin, a long and low headland. The peninsula consists no doubt for the greater part of Permo- Carboniferous shales and sandstones striking about north-south.

Bessimyannii Fjord is comparatively narrow. At the entrance a series of shoals runs in the direction of the strike across the fjord, and therefore the passage is somewhat difficult. The fjord is 15—18 km. long, and in the south-eastern end is an extensive river delta.

The fjord along with the lowland to the east is a glacier trough, narrow at the mouth and widening inwards. The southern side of the fjord is rather steep with a long and continuous cliff from the entrance to the said delta. On the northern side there is a well defined undulating foreland. This foreland rises slightly from the level of the fjord to about 200 m., reaching a maximum breadth of 3—4 km. The lowland is bounded to the east by a canyon-like river valley (compare map of the Bessimyannii Fjord p. 11 in HOLTEDAHL: Brief Account of the Expedition). East of this valley the mountains rise abruptly from the delta plain. (Pl. II, fig. 2.)

About half a km. west of the just mentioned valley a river makes its way through a flat ice-worn valley down to a broad and flat cup-shaped depression, whose bottom lies from 180—127 m. a. s. l. An indeterminable fragment of a shell was found at about 170 m. From this depression to the sea the river valley is a continuous canyon. At the outlet of the trough the canyon is 28 m. deep, but the depth decreases to 15—10 m. farther down. The ridge cut by the canyon at the outlet lies 155 m. a. s. l., and close below the ridge there is a shoreline engraved in loose material at 120 m. As the body of water in the river was small at the time of the visit, the river bed could be followed down the canyon to 62 m., where a waterfall barred the passage. Below the waterfall the river was followed once more to 30 m., but from that point the canyon was so narrow, and the water course had such a foaming speed that it was quite impossible to pass along the river bed farther downwards. Near the mouth the river turns off to the left and leaves her canyon, captured by another river in a canyon close by. The lower part of the canyon such quitted by the river has been filled up by marine sediments to about 40 m. between walls rising to about 50 m. a. s. l. This filling of sediments must have taken place while the shore-line lay about 57 m. higher than now.

At the mouth of the river 5—30 m. a. s. l. the following shells were found:

Astarte borealis, Chemn., 7 v., the dimensions of which were 36/42, 30/37, 27/36, 27/34, 32/39, and 26/34,
Mya truncata, Lin., 1 v., defect,
Saxicava arctica, Lin., 1 v. 18/36.

On the southern side of the fjord, at the most western part of the delta, are two shallow valleys. Farther to the west the mountain wall is entirely unbroken. Several shore-lines are there to be seen from the top of the cliff to about 200 m., but there was no occasion for measuring them. On the northern side of the fjord the shore-lines were very imperfectly developed. Besides the 57 m. line and the 120 m. line mentioned before, a somewhat effaced line about 212 m. was traceable. Perfectly developed was a ledge in a mountain ridge on the western side of the canyon that bounds the lowland to the east. This ledge, an old rocky beach, lies about 240 m. a. s. l. This level has also been found on the southern side of Gribovii Fjord, and is therefore a marine level.

The peninsula between Bessimyannii Fjord and Gribovii Fjord is most elevated in the western part which rises to about 560 m. (1841 Russian feet) according to the measurement of ZIVOLKA (69, p. 52). Towards the east the height is decreasing, and at a defile between the fjords in the continuation of the before mentioned canyon that bounds the lowland to the east, on the northern side of Bessimyannii Fjord, it does not surmount 370 m. at the divide. A saddle-shaped lowland connects the head of Gribovii Fjord with the delta in the Bessimyannii Valley, rising to about 130 m. From Bessimyannii Fjord along the western border of the peninsula, to Gribovii Fjord runs a narrow strandflat, whose outer border faces the sea with a continuous cliff (cp. 20, p. 30). A photograph from this cliff-coast is reproduced in HOLTEDAHL's paper (30), pl. III.

The peninsula is free from ice, but in northeasterly direction from the heads of the fjords some small valley glaciers or cirque glaciers are to be seen, ending about 220—300 m. a. s. l. (cp. 67).

The outer part of Gribovii Fjord is a broad basin with several islands and islets which form parts of the strandflat that stretches northwards in the direction of Matotchkin Strait, 4—5 km. wide. From the outer cliff this strandflat rises slightly to 90—100 m. a. s. l. Along the northern side of the fjord it passes by degrees into an undulating lowland that rises from the level of the fjord to about 200 m., and is broken by a ridge about 400 m. which with decreasing height approaches the fjord.

On the southern side of the fjord steep mountain walls prevail west of a valley which, through the previously mentioned defile, communicates with Bessimyannii Fjord. Near the sea this valley is a deeply eroded canyon.

As several shore-lines were fairly well developed along this valley a levelling was undertaken. The following shore-lines were found and measured:

2,6 metres,
14,5 „ , a beach on the western side of the river,
20,9 „ , a quite distinct shore-line, in some places easily seen also on the opposite side of the fjord,
31,1 „ , sharply developed on the northern side of the fjord in a gully. In the locality it was indistinct.
42,8 „ , a distinct shore-line on the northern side of the fjord,
57,8 „ , a strongly engraved shore-line above a flat beach on the west side of the river valley and quite distinct on the north side of the fjord,
72,3 „ , a shore-line not so well developed as the former but easily seen on both sides of the fjord,
81,7 „ , a shore-line. From this line one has a plain view of the strandflat. It was esteemed to be 4—5 km. wide to the north along the coast and 6—7 km. in the direction of the mouth of the fjord.
99,4 „ , a shore-line visible all around but not distinct except at the base of a rounded knoll at the inner border of the strandflat,
110,0 „ , an effaced line,
121,9 „ , a distinct shore-line with a level beach,
144,7 „ , an effaced line,
153,6 „ , a rock ledge with a beach on the west side of the valley,
158,5 „ , a distinctly engraved shore-line,
184,4 „ , a beach,
212,9 „ , a well developed beach below a cliff at the base of a crag on the east side of the valley.

Just below this crag 10 metres above the bed of the river and 160 metres above sea level, the following shells were found:

Mya truncata, Lin, 3 v. and 50 fragments,

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Saxicava pholadis, Lin. 2 fragments.

The fragments of *Mya truncata* represented both great and small specimens, and some shells were exceptionally thick.

On the west side of the valley runs a flat-bottomed passage between a sandstone ridge to the west and a dolomite crag to the east in north-easterly direction. In the middle of this passage, 200 m. a. s. l., 11 fragments of *Saxicava pholadis* and some dubious fragments of *Mya truncata* were found besides small pebbles 4—5 mm. across. There has consequently been a time when this defile was a sound, and the shore-line at 212,9 m. is therefore certainly a marine level (Pl. III, fig. 1).

By following the river valley to the south in the direction of Bessimyannii Fjord a shore-line was observed at 240 m., thus at the same height as the before mentioned rock ledge on the northern side of Bessimyannii Fjord. Farther to the south several flats with corresponding lines were found at 270, 310, 325, 350 and 370 metres above sea level. On the flats and in the lines water-worn pebbles were everywhere to be seen, and the lines did not in the least differ morphologically from true shore-lines (Pl. IV, fig. 1, 2 and 3).

The 240 m. line lies in open situation against the sea both at Gribovii Fjord and Bessimyannii Fjord and must therefore be a marine level. As to the higher lines it must be admitted as a possibility that they may have been formed in ice dammed lakes between the ice front and the more elevated land to the west during the stage, when the two fjords were filled by glaciers that were connected through the low passage to the east, while the higher western part of the peninsula was left free from ice. The marine origin of these shore-lines is, however, more probable.

The flats and lines from 240 to 370 metres were measured by means of two aneroids read three times.

The lowland between the head of Gribovii Fjord and Bessimyannii Fjord has been submerged to at least 185 m. below the present sea level after the recession of the last ice sheet, for two shore-lines have been observed along its western border, 160 and 185 m. a. s. l. Hence the peninsula has not been covered by the ice since the land was submerged to the 185 metres level; only some local glaciers seem to have existed later on in sheltered localities, for instance the glacier that filled the trough on the north side of Bessimyannii Fjord.

The landforms show plainly that the glaciers were nourished from the north-east and moved against the southern flanks of the fjords, where they were turned off to the west. The southern side of the fjords, therefore, are more intensely eroded than the northern sides, and no remnants of the strandflat are there to be seen. According to the Russian soundings in Gribovii Fjord the inner part of the fjord is deeper than the sounds between the islets and skerries at its mouth, and the bottom is hard and stony. The same is probably true on behalf of Bessimyannii Fjord. These fjords may therefore be assumed to be shallow rock basins. The lowlands on the northern sides of the fjords are partly ice-worn remnants of the strandflat, while the more elevated parts have got their forms solely through ice action.

The fronts of the ice lobes did hardly pass beyond the mouths of the fjords.

Between Gribovii Fjord and Matotchkin Strait runs a strandflat, to the south about 4—5 km. wide, but narrowing towards the north. The mountains rise to somewhat greater height than farther to the south, and they have been rounded by the inland ice. Local glaciers have later on in some degree dissected the western front by digging out cirques and small valleys. To the immediate south of the Strait is a valley of larger dimensions, the Petshanka Valley, broad and deeply eroded nearly to the level of the sea. In one place in this part of the coast the rock-cliff is missing, and the sea washes out loose material, moraine and marine sediments, instead of working in solid rocks. A glacier has digged out a trough valley in the strandflat which later on has been filled up with the sediments that nowadays are washed by wave action.

2. **Matotchkin Strait and Serebryanka Fjord.**

(Compare pl. XXVII.)

The western part of Matotchkin Strait, the strait that divides Novaya Zemlya into two islands, trends for about 10 km. perpendicular to the strike, then it mainly follows the strike for about 25 km. to Cape Morschevoi. Also farther to the east its direction is rather varying.

The part of the Strait that follows the strike is formed as a typical trough valley. The mountain sides of the middle and eastern parts are also perfectly ice-worn, but not so regurlarly as in the western part. Several valleys open on the Strait, Matotchka Valley from the south near the western entrance, Tchirakina Valley and Choumilika Valley farther to the east. Tchirakina Valley is aboat 10 km. long, and its bottom is eroded down to the level of the sea, Choumilika Valley is not much shorter, and its bottom lies only a few metres a. s. l. Approximately in the direction of Choumilika Valley goes Rosmysloff Valley from the Strait to Serebryanka Bay between Lütke Mts. and Loshkin Mts., a broad and ice-worn pass that rises to about 100—120 m. a. s. l.

The valleys along the middle part of the Strait are generally short with steep dip against the sea. Of these valleys Chalhonik Valley ist best developed. Farther to the east this valley type is much better worked out, and Baer Valley is both broad and deep, a typical ice-worn trough, whose bottom rises only slightly above the level of the Strait. Belushii Bay and Gubina Bay with corresponding valleys are still larger, and so deeply eroded that their bottoms lie below the present sea level.

According to the Russian chart nr. 601 and a Swedish chart published by Kungl. Sjökartverket, Stockholm 1920, the depth of the Strait at the western entrance is about 30 m., at the eastern entrance about 110 m. and in the middle part 150—160 m.

Pomorskaya Bay and Matotchka Valley.

(Cp. text fig. 1.)

Cape Stolbovii west of Bakan Bay on the southern side of the entrance to the Strait is a low projecting part of the strandflat (Pl. V, fig. 1), and so is Cape Matotchka on the western side of Pomorskaya Bay. This bay is, according to the Russian chart, mostly shallow except along the western side where a somewhat deeper channel follows the coast line to east of the mouth of the Matotchka River. Matotchka Valley is broad and perfectly ice-worn and rises slightly inland. The river has two main tributaries, one from the southwest and the other from the east. Near its mouth it passes through an old lagoon, now filled to above high water level and partly drained through the rise of the land. The lagoon has in front a low embankment of sand and pebbles cut by the river near its eastern end. The channel of the river is deep enough for rowing boats to enter the lagoon (Pl. III, fig. 2).

On the embankment three dwellinghouses and a little chapel have been built for a colony of Samoyeds (Pl. III, fig. 2). (The chapel is at the base 3,2 × 3,2 m.^{2}). According to a levelling the southeastern corner of the chapel lies 3,83 m. above high water mark. The difference between high and low water was determined to be 1,10—1,20 m., and the top of the embankment therefore lies 4,40 m. above the middle water line. On the sea side of the shingle bank is a shore-line 3 m. a. s. l.

According to SPÖRER (69, p. 52), HEUGLIN (20, p. 43) and more authors the lagoon should formerly have been accessible as anchorage for small vessels and boats. SPÖRER mentions an anchorage with a depth of 6 fathoms one werst inland, which probably means the river at the head of the lagoon. This place, however, is at present not at all accessible, but it may have been usable before the time of ROSMYSLOFF. When the place was visited by LÜTKE the depth of the lagoon does not seem to have been much greater than now, but he found remnants of a great hut on the right bank of the river where no houses are now to be found (46, p. 243).

In order to favour a future determination of an eventual rise of the land a brass tube, marked 21. August 1921, was plugged down into the rock (cp. pl. VI, fig. 1) about 540 m. from the chapel in northwesterly direction. DIETRICHSON who fastened the tube fixed the base of it to 0,30 m. above high water, and I found 0,20 m. There was no occasion of controlling the relative value of these measurements.

Matotchka River runs on the bottom of a typical trough valley, the head water cutting a canyon in the rocky ground. The tributary from the southwest may have worked for a shorter time in its furrow as there is no canyon. Between this valley and the main valley a mountain top rises to about 600 m. (esteemed) 7—8 km. from the bay.

The tributary from the east runs in a narrow valley in the eastern mountain wall. Just north of this river a broad terminal moraine projects between the mountain side and the main river, the surface sloping towards the west from 160 to 110 m. At the middle of the ridge, 120 m. a. s. l., the following shells were found:

Mya truncata, Lin, 2 v. and 16 fragments,

Saxicava pholadis, Lin, fragments of at least 4 specimens.

Near the river the moraine turns to the right and runs northwards along the river. This part of the moraine holds a good many large sharp-edged blocks and ends about 90 m. a. s. l. It faces the river with a steep bank but slopes faintly towards the east. There can be no doubt that this stony part of the moraine is an old middle moraine, the material of which has been taken from the sides of the previously mentioned mountain between the valleys to the south.

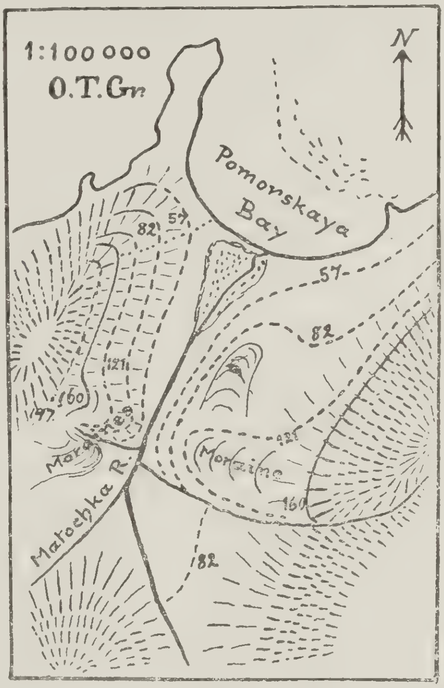

Fig. 1. Sketch map of Pomorskaya Bay and Matotchka Valley.

On the western side of the valley is the continuation of the terminal moraine, but here are two ridges. The valley or gully between these projecting moraines has rather steep sides, is short and narrow, with a small rivulet. The ridge to the north of this valley reaches farther into the main valley than the other and rises to 160 m. It consists for the greater part of clay with a top layer of sand, gravel and pebbles.

The southern ridge is 180 m. high and consists of gravel and pebbles; clay has not been observed. It rises steeply both from the gully and the main valley (cp. 67, fig. 4).

On the inland side of the first mentioned ridge the following shells were found 65—70 m. a. s. l., mostly in clay:

Pecten islandicus, Müll, 15 v. and 31 fragments of great and middle-sized specimens,
Leda minuta, Møll, 3 v. and 2 fragments,
Astarte borealis, Chemn, 141 v. and 61 fragments. Medium size 25 32.
Astarte eliptica, Brown, 12 v., medium size 17/24.
Astarte montagui, Dellwin, var. *striata* 11 v., var. *warhami* 1 v. 7/8,
Cardium grønlandicum, Chemn, 8 v. and 22 fragments,
Macoma calcaria, Chemn, 28 v. and 26 fragments of great specimens,
Mya truncata, Lin, 33 v. and 90 fragments,
Saxicava arctica and *pholadis*, Lin, 17 v. and 7 fragments of great specimens,
Tectura rubella, Turt, one specimen,
Neptunea sp. (*despecta*?), one columella,
Bela trevelyana, Turt, var. *novaja-semljensis*, Leche, 2 specimens.
Balanus sp., 8 fragments.

Besides the shells spines of an *Echinus* and some foraminifers were found. A fragment of a gastroped with two by two longitudinal ribs and transverse striæ is considered to belong to a *Buccinum* sp.

On the front side of the other moraine ridge, from the rivulet upwards, between 140 and 170 m. a. s. l., the following species were found:

Astarte eliptica, Brown, one fragment,
Mya truncata, Lin, 2 v. and 16 fragments,
Saxicava pholadis, Lin, 5 v. and 6 fragments.

The top of the moraine lies about 186 m. a. s. l. and is covered by vegetation, but where the shells were found the slope was so steep that the surface layer was slowly sliding downwards to the rivulet. At 170 m. only *Mya* and *Saxicava* were to be seen.

By levelling from the shore west of the Samoyed houses along the dotted line on the sketch map the following shore-lines were pointed out:

3,0 metres, a shore-line on the front side of the shingle bank,
14,1 „ , an effaced shore-line, extremely difficult to fix,
25,4 „ , — — —„— uncertain determination.

32,3	metres,	a distinct shore-line below a 7,8 metres high bluff; visible on both sides of the valley. The elevation of the top of the cliff to the west of the bay. Above the edge of the bluff is a flat 325 m. wide, falling 5° to the east.
40,0	„ ,	a shore-line that can be pointed out, but the measurement is uncertain,
56,5	„ ,	a strongly engraved shore-line below a bluff 8 m. high,
71—72	„ ,	a shore-line uncertain but visible,
82,9	„ ,	a shore-line developed as the 56,5 m. line but not quite so sharp. At 98—100, 107 and 115 faint lines.
121,9	„ ,	a distinct shore-line, but somewhat difficult to fix,
135,0	„ ,	a shore-line above a beach,
137—138	„ ,	a faint line, but visible on the eastern side of the valley,
156,0	„ ,	a broad rock ledge on both sides of the valley,
159,6	„ ,	the corresponding shore-line,
197,0	„ ,	an even beach with pebbles. Only distinctly developed at the northern projection of Mt. Matotchka (Pl. V, fig. 3). Measured by aneroid.
215,0	„ ,	a notch cut in the mountain ridge close above the former beach.

The last mentioned strandmarks have not been observed on the eastern side of the valley.

Most of the levelled shore-lines can be followed continuously to the moraines. The 160 m. line is more sharply engraved than any other line on both sides of the valley but it disappears, however, at the moraine.[1] A lateral moraine is traced along the western side of the valley to the terminal moraines at 200 m. The land inside the last mentioned moraines has been surveyed by means of the levelling instrument, but no lines were to be seen above the 83 m. line. This line and the 32 m. line are faintly visible.

By surveying the eastern side of the valley it appeared that above the 32 m. line the shore-lines were engraved in hard morainic matter. The 160 m. line does not only disappear at the terminal moraines but also to the north-east in the direction of the Strait where it is replaced by a lateral moraine that consists of both sharp-edged and rounded blocks. The block moraine rises to above 220—230 m.

The way in which the shore-lines appears, shows that while the land was submerged to the 215 m. level only the northern projection of Matotchka Mt., to the west of the valley, was accessible to the attack of the sea. When the 197 m. line was engraved, the ice front had withdrawn to the terminal moraines, but not till the time of the 83 m. line was the valley inside these moraines free from ice. If the valley later on has been glaciated, the glaciers did not reach this shore-line, but as the 56 m. line that everywhere else has been distinctly engraved can not be traced inside the moraines, it is probable that the valley floor at the corresponding time to some extent was covered by a glacier with a front reaching the sea.

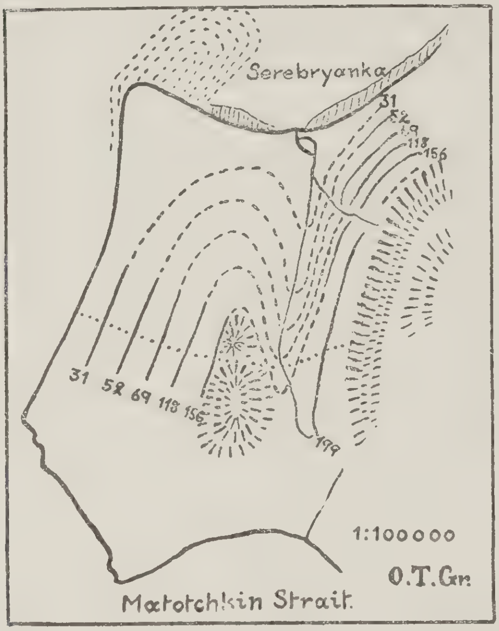

Fig. 2. Sketch map of the country between the Strait and Serebryanka Fjord.

As before mentioned some morainic material has been observed in the middle of the valley in front of the moraines to the east of the river. No such accumulations have been observed on the western side, only marine sediments, a grey sand-mixed clay.

Serebryanka Fjord.

(Cp. fig. 2).

On the north side of the western entrance of the Strait is a wide strandflat between the coast line and Lütke Mts. stretching northwards to Serebryanka Bay. The most westerly point is Cape Serebrannoi. The northernmost part of the flat does not rise higher than 30 m., the northern border adjoining Serebryanka Bay where there is a good anchorage close off the shore at the mouth of a small river.

Just at the mouth of the river is a lakelet, a former lagoon, behind a bank of gravel and pebbles that is passed by the river in a rapid. The river runs in northerly direction, and is about 5 km. long. Some hundred m. above the lake it receives an affluent from the mountains to the east.

The strandflat faces the sea in an almost continuous cliff from the anchorage all round the peninsula. From a break in the cliff with a sand beach a levelling was undertaken with the following results:

3,9 metres, a shore-line with a notch in the southeastern point of Mityoucheff Island,
10,5 „ , an effaced shore-line. A notch in the said point.

18,2 metres, the top of the cliff to the north of the locality. From the edge of the cliff rises a flat with 5° ascent to

30,9 „ , where there is a shore-line below a bluff 11,3 m. high, an old cliff partly destructed by the weathering. On the island a shore-line has been developed all round in this level,

42,2 „ , an effaced shore-line above the cliff. From thence a flat 150—200 m. wide with 3°—3,5° ascent rises to

52,2 „ , where a shore-line runs below an old cliff 8 m. high. On the island this line was visible but not distinct. From 59,2 m. is a flat 100—120 m. wide to a good shore-line at

68,5 „ . In this level lies the highest point of Mityoucheff Island. The bluff above the line is 4,1 m. high. From here a flat to

79,0 „ , a shore-line, not distinct,

102,5 „ , a faint line. Then a flat 400 m. wide to

118,2 „ , a distinct shore-line below a cliff.

137,6 „ , a shore-line below a cliff.

156,3 „ , a very distinct shore-line below a cliff. This measurement is somewhat doubtfull, for at 152,7 there also seemed to be a line. From here was a steep ascent with a cover of decomposed material to a flat with corresponding shore-line at

175,5 „ . Here the levelling crossed the river before mentioned. The river runs rather swiftly in a relatively narrow valley. At

198,7 „ is the uppermost shore-line on this locality. It is a very distinct line with a beach of water-worn pebbles of quartzites and dolomites.

Above this shore-line is a steep talus with blocks of porphyritic granite from the solid rock higher up. Besides the blocks of granite also blocks and boulders of diabase, quartzites, and a green slate were noticed. About 270 m. a. s. l. there was a huge lateral moraine terrace running along the mountain side in northeasterly direction.

From the sea shore to about 180 m. there is no moraine material at the surface. Only marine sediments on the flats and decomposed rock detritus in the old cliffs have been observed, but above 180 m. the ground-moraine crops out. The inner border of the strandflat could not be fixed with certainty, but it is assumed to be situated between 100 and 118 m. above the present sea level.

Near the river in the before mentioned valley between 150 and 142 m. a. s. l.

Saxicava pholadis, LIN, 3 v. and some fragments were gathered.

The lower part of the valley is relatively flat, and along the sides a 11 m. line and a 20 m. line were to be seen all around. On the eastern side of the valley the 31 m. line runs along the edge of a steep bluff, and above the line is a flat, 200 m. wide, rising to the 53 m. line at the base of a steep moraine slope 12 m. high. On the northern part of Mityoucheff Island this level is also represented by a wide flat and corresponding bluff or cliff, and it therefore seems to be a main level. The 69—70 m. line and the 79 m. line were but faintly engraved in the hard and stony moraine material. They are visible, however, to the west of the river. The 156 m. line is sharply engraved with masses of water-worn stones and pebbles but the broad beach is in some places heavily loaded with sharp-edged blocks from the mountain ridge above. Following this terrace in northeasterly direction one arrives into a small valley where a glacier descends to about 200 m. Here the 199 m. line was found once more. Besides blocks of a grey granite, some blocks of a red granite were observed. On account of a lateral moraine the glacier must once have advanced farther down the valley.

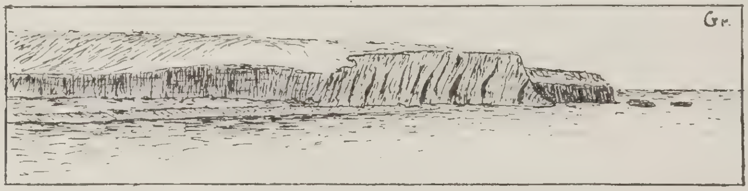

Fig. 3. Sketch of the cliff close to the west of anchorage 17, Serebryanka Fjord, showing that the strandflat has been scoured by the ice before the cliff was formed.

At the mouth of the river there is no cliff. The shingle bank that is damming the lakelet, contains water-worn pebbles of a multitude of rocks; for the most part, however, pebbles of the dark dolomite in the cliff close to the west. On the present beach no shells were observed besides a single specimen of *Pecten islandicus*, quite recent-looking.

To the west of our anchorage the outer border of the strandflat has been rounded through ice action, for a few hundred metres along the southern side of the fjord (Fig. 3). The part of the strandflat which was visited was rather poor in shells. At 20 m. only two species were found:

Mya truncata, LIN, 3 v. and 3 fragments and
Saxicava pholadis, LIN, 5 fragments.

Near the cliff 10 m. a. s. l. two more species were found:

Pecten islandicus, MÜLL, one small specimen and
Mytilus edulis, LIN, 1 v. of common size.

Serebryanka Fjord and Valley stretches in northeasterly direction, in the broad features parallel to the strike of the rocks. A remnant of a primary larger and more continuous strandflat is the Mityoucheff Island off the mouth of the fjord, and so is the lowland on the north side of the entrance with a cliff facing the sea similar to the one on the southern side just described (Pl. VII, fig. 1). The inner part of the fjord passes between high mountains, Loshkin Mts. to the east and Mityoucheff Mts. to the west. It is steep-sided without cliffs and no remnant of the strandflat is to be seen. According to ZIVOLKA the Mityoucheff Mts. rise to about 1000 m. They consist of granitic rocks. The eastern side against the fjord is strongly battered by the weathering and dissected by the action of a number of cirque glaciers, but the western side is finely rounded by a glacier that once, advancing from the inner land, traversed both Serebryanka Fjord and Mityoucheff Mts. The dissected and weathered landform on the east side of the mountain ridge is of a later date.

At the head of the fjord is a large delta through which the Serebryanka River winds its way to the sea. The aspect of the recent delta compared with the Russian maps shows that the delta must have considerably increased since the head of the bay was mapped (assuming that the maps are correct with regard to the delta) either on account of a silting up of the inner part of the fjord or by rise of the land, or by both causes acting together (Pl. V, fig. 4).

Inside the delta is a terminal moraine rising to 30 m. a. s. l. It has been accumulated by the northmost glacier on the east side of the Mityoucheff Mts., but the glacier has retreated since the moraine was built up, and the glacier tongue does not at present descend below 73—74 m. a. s. l. This glacier communicates through a gap in the mountain ridge with a glacier on the western slope of the ridge descending to a horse-shoe shaped terminal moraine near the shore of the bay there. The other glaciers on the east side of Mityoucheff Mts. are typical cirque glaciers and do not descend below 190 m. a. s. l.

The lower shore-lines are visible on both sides of the fjord. The 31—32 m. line is distinct, and the 42 m. line forms the inner border of a flat, 40—50 m. wide, with a corresponding notch in the mountain profile to the southwest. The 57 m. line is not distinct, but there is a deep notch in the profile mentioned at this level. The 80 m. and 100 m. levels were only faintly developed, but in a single place there was a terrace washed out by the sea in morainic material 102 m. a. s. l. The 121 m. level was distinct with ledges. Between 121 and 170 m. no shore-lines were to be seen, but there was a distinct, shore-line with ledges in several places, especially on the western side of the fjord, and a notch in the said profile at 175 m. At 192—195 m. a lateral moraine was observed.

The Serebryanka Valley is broad and flat, and the bottom rises slowly to the northeast. It communicates with the Strait through a flat side valley with southeasterly direction east of Loshkin Mts., presumably not surpassing 120 m. Along the eastern side of this valley two shore-lines were to be seen. Their height could not be stated with certainty as they were too far away. Through aim with the levelling instrument the uppermost one was determined to lie between 175 and 190 m.; the lower one was assumed to be the 121 m. line.

The Middle Part of the Strait.

Between Cape Baranyi east of Pomorskaya Bay and Cape Morschewoi the Strait is quite shallow. According to the charts at hand the depth varies between 7 and 12 fathoms. ROSMYSLOFF who undertook the first soundings known from the Strait found 9—15 saschens (fathoms). As it is not presumable that his soundings in so shallow waters should be erroneous, this difference may suggest a rise of the land during the last 150 years amounting to 3—4 m. in this part of the Strait.

On the western side south of Rosmysloff Valley stretches a foreland 1—2 km. wide which in some places has a steep ascent from the sea, in other places rises with a slower grade. The height is about 80—90 m. along the steeply rising mountain sides behind. It passes by degrees into the bottom of Rosmysloff Valley. Farther to the north the width of the foreland is decreasing, and it fades away about 4—5 km. southwest of anchorage 4.

On the eastern side of the Strait a foreland is also developed between Tchirakina Valley and Choumilika Valley (Pl. VIII, fig. 2), but north of this valley a cross-section of the Strait is seemingly that of an unbroken parabolic curve from the level of the sea to about 400—500 m. (Pl. VII, fig. 2).

The most eastern one of the Lütke Mts. was mounted from the east opposite to the northern border of the Tchirakina Delta by O. HOLTEDAHL and the author. A surface-cover of the weathered detritus of a dark phyllitic slate made the ascent somewhat troublesome. Erratic blocks were nowhere to be seen on the mountain sides, but on the top more boulders of foreign rocks were observed, chiefly of a dark green diabase and grey quartzites. The top has an elevation of 680 m. according to measurements with three aneroids. The Russian map indicates a somewhat smaller height, viz. 1890 feet. The mountain is ice-worn all over by an inland ice which has passed from east-northeast.

Shore-lines were to be seen both along the Tchirakina Valley and between this valley and Choumilika Valley, often marked by horizontal stripes of snow. No lines, however, were good, and no locality was seen to be fit for levelling. On the southern projection of Mt. Lasareff north of Choumilika Valley they were better developed, but there I had no opportunity for levelling. About 4—5 km. farther to the north after passing a narrow channel between sand shoals in the Strait a levelling was undertaken at anchorage 3 with the following result:

3,9 metres, a shore-line at the inner border of a lagoon,
18,3 „ , a shore-line visible on both sides of the Strait,
37,5 „ , a very effaced shore-line, impossible to fix correctly,
48,5 „ , a doubtfull shore-line, the measurement therefore uncertain,
58,1 „ , a quite distinct shore-line especially on the northwestern side of the Strait,
86,2 „ , a shore-line developed as the former line,
124,3 „ , a quite distinct shore-line,
147,2 „ , an effaced line.

The locality was not at all favourable, but the levelling was yet carried on to a height of 160 m. No shore-line, however, could be pointed out with certainty. The loose material was a ground-moraine in which plenty of great blocks were embedded, among others huge blocks of a coarse conglomerate. One of the blocks was estimated to 4 m.^{3}. As the mountain side was overspread with great stones the measurements were proceeded by aneroid. The uppermost line in the locality was found 185 m. a. s. l., a very doubtful shore-line, more probably a lateral moraine.

It must be pointed out that all the mountains: flanks, ridges and summits on both sides of this part of the Strait have been rounded and scoured by the ice. Both the Strait and the adjoining valleys are glacier troughs. The sides and bottoms of the valleys are strongly worn by the ice. The land must therefore once have been strongly glaciated, but on account of the intense weathering, scratchings are nowhere to be seen.

At Cape Morschewoi (Walrus Cape) the trend of the Strait changes from northeast to east southeast at nearly a right angle. From this point to east of Cape Uzkoi lofty mountains rise on both sides of the Strait. Summits and ridges not surpassing 900—1000 m. are rounded and ice-worn all over, but the higher tops often have sharp, conical peaks surrounded by talus either of weathered detritus of schists, or of blocks of more compact rocks in a very instable equilibrium. If the peaks are original nunataks, or if they have got their sharp forms after the waning of an ice sheet that once overstepped them, is a question not easily answered. Count Wilczek and Höfer who climbed the Wilczek Spitze, one of the highest peaks north of the Strait, found a flat on the summit which may be a remainder of a former ice-worn rock surface. It is therefore probable that primary nunataks do not exist at all even in this loftiest part of Novaya Zemlya, where a great number of the mountain tops seem to reach an elevation of above 1100 m.[1] (Pl. IX, fig. 1, pl. XI, fig. 1.) Between the ridges and summits on both sides of the Strait are large ice filled troughs from which glaciers descend. The valleys are generally short with a steep ascent. South of the Strait the mountains pass into a plateau land with an elevation of about 600—700 m., sparcely dissected.

On both sides of the Strait east of the said Cape lateral moraines are forming the edge of a glacier trough with a terminal moraine at the Cape. On the northern side of the Strait just opposite the Cape the dolomite rocks have a heavy cover of morainic material with a multitude of erratic blocks of foreign rocks, chiefly coarse diabase types and quartzites.

At the Cape (anchorage 4) a levelling was undertaken with the following results:

4,7 metres, a good shore-line on both sides of the Strait,
23,3 „ , - — — — — — —
48,0 „ , - — — — — — —
61,1 „ , - — — — — — —
74,7 „ , - — — not good but can be pointed out,
90,2 „ , - — — — — — —
128,7 „ , - distinct shore-line on both sides of the Strait,
190,4 „ , - — ledge of morainic material.

No shore-lines above the 128,7 m. level were to be seen.

From the Cape the lateral moraine runs in southeasterly direction along the mountain slope, at the Cape rising to 240 m. but reaching gradually a height of about 270 m. one km. farther to the southeast. As the mountain side here retreats, space is left for a foreland, 500—600 m. wide, between the sea shore and the mountains, consisting of ground-moraine with a top-layer of marine sediments. From the shore is a steep ascent to about 30 m., then a slow and even slope to 130—140 m. On the flat two shore-lines were observed about 80 and 129 m. a. s. l. In the mountain side above the flat a distinct moraine terrace was to be seen 195 m. a. s. l. At about 350 m. there was an even, intensely ice-worn rock surface with huge blocks of dolomite undoubtedly taken from the 1000—1100 m. high dolomite mountain a few km. to the east. The local rocks were greenish schist and some small ridges of dolomite.

At anchorage 16 close to the east of the dolomite mountain just mentioned, flats of morainic material washed by the sea were seen on both sides of a valley. The height was about 85 m. Higher up the valley an advanced glacier-lobe ends 180—190 m. a. s. l. The glacier tongue[1] was surrounded by a horse-shoe shaped terminal moraine, and some metres below this ridge was another of the same shape, built during an advance of the ice. Between the glacier and the flats no moraines were to be seen, but below the flats, about 76 m. a. s. l., were two advanced moraines along the valley sides. A small glacier therefore seems to have passed across the 85 m. flat in the direction of the sea. The moraine ridges have been planned by wave action (Cp. 67, pp. 14—15).

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[1] A panoramic view of the Wilczek Mts. is reproduced in Holtedahl's paper on the Rock Formations, this Report no. 22.

East of the valley a heavy ground-moraine connected with lateral moraines covers the ground to a considerable extent. Shore-lines were observed at 19, 23, 40, 50, 68, 78, 85 and 92 m. About 10 m. a. s. l. a single specimen of *Astarte montagui*, Dellwin, var. *warhami* was found with dimensions 18/22. On the valve remains of a brown periostracum were seen. 85 m. a. s. l. *Mya truncata*, LIN, a fragment, and *Astarte montagui*, Dellwin, 1 v. 18/22 were found. The last mentioned specimen of *Astarte* was somewhat worn, but it is presumed to be var. *warhami*. On the shell were remains of a nearly black periostracum.

At 110 m. a. s. l. there was a distinct line in the moraine, presumably a shore-line, and at 140 m. there was a strong moraine terrace with blocks of dolomites, diabase and quartzites. This terrace had seemingly not been submerged below the sea surface. About 240 m. is a fainter terrace. These moraine terraces rise about 10 per cent to the south-east. They are lateral moraines deposited by a glacier that once advanced down a valley close by, now entirely free from ice. Shore-lines do not rise higher than 110—120 m. in this place. Opposite this valley on the northern side of the Strait there is a valley in which three terminal moraines are to be seen. Also this valley is now free from ice.

On the northern side of the Strait in northeasterly direction from anchorage 4 is the Tretyakoff Glacier, the greatest glacier that advances to the Strait (Pl. IX, fig. 1). Its valley is broad and short. The glacier rises by the conjunction of three (or four, 67, p. 15) tributary ice streams. The glacier tongue descends to about 10—15 m. a. s. l. enclosed by two horse-shoe shaped ridges. These ridges, apparently moraines, consist for the greater part of ice only covered with a relatively thin layer of morainic material and loaded with stones. The glacier river emerges from an ice cave on the left side of the tongue about 35 m. a. s. l. On the outer moraine ridge 40 m.

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[1] In ROUSSANOFF'S paper (67) a photograph (fig. 13) is reproduced, which is stated to be an illustration of the lower part of this glacier on the south side of the Strait (called Glacier Vélain); as a matter of fact the photograph shows the terminal moraines of the Tretyakoff Glacier and the Strait further east. Cp. pl. XI, fig. 1 of the present paper.

a. s. l. two specimens of *Astarte borealis*, Chemn. were found, the one with a well conserved periostracum. The sample is lost as the find was the first one of that kind and therefore not duly estimated.

The lateral moraines that border the glacier trough indicate that the glacier has formerly been more advanced. Three stages can be pointed out. During the first stage a fan-shaped broad glacier-lobe extended into the Strait. The surface of the ice lay then at least 50 m. higher than now. During the next stage the glacier scarcely advanced beyond the present shore-line. At that time the land in the vicinity of the glacier seems to have been submerged to about 60 m. below the present sea level. The third stage was not much different from the present one.

At present the movement of the glacier is quite inconsiderable. The most advanced part is reduced into stone-ice without crevasses or fissures, and no river emerges at the base. As the moraine was fossiliferous these conditions must have lasted for a long time. Now the glacier is retiring from the second moraine ridge. The growth of the delta in front seems to be slow.

About 10 km. farther to the east (anchorage 5) is Chalhonik Valley deeply excavated with a large delta stretching into the Strait.[1] To the west of the delta the land is covered by marine sediments and has an even slope. The shore-lines were indistinct, possibly to some extent destructed by the flowing of the soil. The locality was for that reason not fit for levelling. The first shore-line which could be pointed out lay 65 m. a. s. l. It was not, however, developed in the locality but was only seen on the opposite side of the Strait. A 95 m. line was easily pointed out all around, especially on the south side of the Strait, opposite the delta. More distinct than any of the lower shore-lines, however, was a shore-line 133 m. a. s. l. on both sides of the Strait. This line is the uppermost shore-line that could be pointed out in the middle part of the Strait.

From the 133 m. line the ground rises abruptly to an ice-worn saddle 320 m. a. s. l. The glacier that once overstepped this saddle must have had its surface at least 400 m. above the present sea level, while the glacier which at the same time filled the middle part of the Strait scarcely reached an elevation of 300 m.

Inside the saddle there is a small cirque glacier enclosed by a moraine about 200 m. a. s. l. Near the front of the ice-lobe, at 240 m., there was a round hole in the ice, about 20 m. across. In front of the glacier 180 m. a. s. l. was an old moraine showing that an advance once had taken place.

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[1] A panoramic view of this part of the Strait is reproduced in HOLTEDAHL's above mentioned paper.

At the upper end of the delta a terminal moraine crosses the valley. On the western side of the river this moraine has an elevation of about 115 m. but to the east of the river the height is greater, about 130 m. at the entrance of a side valley from the north-east (Pl. VIII, fig. 3). On the front side of the moraine no shore-lines have been observed, but, inside the cut through which the river passes the moraine, there are three shore-lines about 60, 75, and 90 m. a. s. l. The 133 m. line, however, was not there to be seen, and therefore it must be assumed that the valley was filled by ice up to the moraine at the time when this shore-line was engraved.

About 0,5—1,0 km. behind the said moraine three more moraine steps are to be seen. The first of these is no distinct transverse ridge, but the others are typical terminal moraines deposited by a glacier in the main valley. They rise to 110—120 m., and the distance between them is about 200 m. On account of their form it must be concluded that they never have been washed by the sea. As to the older moraines it is to be noted that they are broad and well rounded and therefore must be assumed to have been deposited below the surface of the sea.

The material of all these moraines contain only few great blocks because they have been deposited by a retiring and waning glacier, but from a cirque on the western side of the valley a glacier descends which partly overlaps the third and fourth moraine, covering them with gravel and a multitude of great blocks. One of the rivers from this glacier runs between the second and third, the next one between the third and the fourth, and the third river runs inside the fourth ridge (Pl. VI, fig. 2).

According to ROUSSANOFF a Mendeleeff Glacier with three moraine ridges in front is to be found in or in the neighbourhood of the Chalhonik Valley. It may be identical with our glacier inside the saddle, but, to judge from ROUSSANOFF's sketch map, it seems more likely that the Mendeleeff Glacier is to be sought for farther inland, probably on the west side of the upper parts of the Chalhonik Valley not surveyed by us (67, p. 9 and pp. 12—23).

From the delta of Chalhonik River the Strait for some km. turns in southeasterly direction. At Cape Rosbiwnoi (anchorage 6), close to the east of the advanced delta of the Ekstam River on the south side of the Strait, a levelling was undertaken. The locality was not favourable for levelling, but it was, however, the only one tolerably fit for the purpose.

The measurements gave the following results:

Steep ascent to above 25 m. No shore-lines to be seen.

29,2 metres, a shore-line very difficult to fix exactly,

46,0 „ , - — — — — —

61,3	metres,	a safe shore-line. The level controlled on the return.
75—80	„ ,	an effaced shore-line, impossible to fix correctly,
85,1	„ ,	a very distinct shore-line on both sides of the Ekstam Valley to the west,
116,8	„ ,	a very distinct level both in the valley sides and on the opposite side of the Strait. Close below the shore-line a terrace 40 m. wide,
139,8	„ ,	a distinct level on both sides of the Strait,
156,0	„ ,	a shore-line with a terrace or ledge in moraine material,
170,5	„ ,	a level on both sides of the Strait, probably a lateral moraine,
220,0	„ ,	a moraine level.

A multitude of foreign blocks were spread all over, chiefly of a green spotted diabase, quartzites, sandstones, strongly pressed, and folded limestone of the same type as that seen in the mountains west of anchorage 5 etc. There is reason to believe that the moraine cover, in which the shore-lines have been engraved, has been deposited in this locality by a glacier that advanced along the Strait, for about 3 km. farther to the east the Strait is for some hundred metres partly filled up with sand shoals, a true parallel to the sand-filled passage in the western part of the Strait south of anchorage 3; and, besides, several lateral moraines converge against this point. Between these relatively shallow passages the depth of the Strait is for the most part considerable, and this part of the Strait must therefore be assumed to be a rock basin excavated by the ice. From the lateral moraines can be inferred that the surface of the last glacier that barred the Strait between the said points lay about 300 m. above the present sea level at anchorage 5, 240 m. at anchorage 4 and 220—230 m. at anchorage 6. The land was at that time submerged to about 160—170 m. in this part of the Strait, for only there the 160 m. line has not been developed.

The Ekstam River runs in a deep canyon (Pl. XVIII, fig. 2) mostly cut in phyllitic schist. The river passes the western end of a terminal moraine in a furrow younger than the moraine, for only the upper parts of the walls consist of moraine material. The top of the moraine lies 105 m. a. s. l. and has once been washed by the sea. The stones in the moraine are relatively small and well rounded. Inside the moraine is a small depression in which the 85 m. level was to be seen. On the western side of the valley is a great cirque glacier surrounded by two or three moraine ridges. The outer ridge has partly overlapped an ancient grassgrown land surface.

From the Ekstam Valley the Strait runs for about 5 km. in easterly direction to the delta in front of Baer Valley (Pl. IX, fig. 2). On the delta masses of drift-wood are to be seen to about 5 m. a. s. l. The Baer Valley must once have been filled by a large glacier with a broad front advancing into the Strait, for at the entrance of the valley heavy lateral moraines stretch diverging forward on both sides. This glacier was probably contemporaneous with the above mentioned glacier that locked up the Strait. The uppermost shore-line lies about 160 m. a. s. l., a lower line about 115 m. (aneroid). From the 115 m. line a long moraine ridge runs towards the sea on the east side of the delta, about 35 m. high. A younger glacier tongue seems to have advanced to the upper end of the delta or perhaps somewhat nearer to the present shore-line.

The Baer Valley is strongly ice-worn and deeply eroded like the Tchirakina and Choumilika Valleys. From this fact may be inferred that for a considerable length of time the glacier in the valley had a movement not checked by glacier ice in the Strait. To day the valley is free from ice, at any rate in its lower parts.

Farther to the east lenghtwise valleys appear on the northern side of the Strait, but they have not been so deeply excavated. They are now free from ice in their lower parts seen from the sea.

Close to the west of Syernaya Mt. a river running through a narrow valley with a torrential course enters the Strait. The lower part of the valley is a canyon. On the western side of the valley shorelines have been measured at the heights of 25, 42, 65, 110 and 150 m. a. s. l. Higher up the mountain side lateral moraine lines and terraces are to be found at 280, 320, 400, 460 and 530 m. A block moraine of large stones and boulders covered the mountain slope at a height of 500 m. The blocks were mostly 30—40 cm. in diameter. At a height of about 530 m. the blocks were somewhat smaller, of from about fist to head size, seldom greater. The rocks represented were sandstone, dolomites schists and diverse diabase types. A summit 585 m. high consisted of a thick diabase dyke. Below this top the bottom of the valley was an ice-worn saddle with an elevation of 430 m., and behind the saddle there was a large plate or cup-shaped ground with glaciers advancing to the south without reaching so far down, however, as to be seen from the Strait.

Perched upon the eastern mountain flank a local glacier advanced to the bottom of the valley where its terminal moraines were deposited about 470 m. a. s. l. The upper boundary of the glacier lay about 700 m. Here the situation of the snow-line was determined as follows:

$$\frac{470 + 700}{2} = 585 \text{ m.}$$

This determination does not of course pretend any exactness, but it agrees tolerably well with former determinations that state a height of the snow-line along Matotchkin Strait to 600 m. (cf. 19, p. 111). Which of these figures is likely to be nearest to the fact cannot be safely decided, but I am inclined to think that 600 m. may be too much, for the occurrences of stone ice that Tchernysheff observed between 400 and 600 m. in crossing the middle part of the south island suggest a situation of the snow-line there not exceeding 500—550 m.

A moraine cover, consisting of diabase blocks transported by the ice from dykes to the west, was accumulated on the mountain ridge about 750 m. a. s. l. The highest part of the ridge has an elevation of above 800 m. The rocks in situ are sandstones.

On the eastern flank of the ridge just mentioned facing the Belushii Bay, one meets the upper border of a local glacier, 740 m. a. s. l. advancing down a valley in southeasterly direction to 380 m. where its terminal moraine consisting of sharp-edged sandstone blocks is deposited. Farther down the valley an isolated ice remnant was observed, and at 200 m. a second block moraine crossed the valley floor. The valley opens upon the mountain side as a hanging valley 120 m. a. s. l. The valley has only a slight inclination towards the entrance where there is a rocky threshold cut by the river in a deep canyon. On both sides of the entrance a distinct shore-line had been engraved 130 m. a. s. l., but farther into the valley no shore-lines were to be seen. When the 130 m. line was engraved, the valley must therefore have been filled by a glacier.

Belushii Bay.

Belushii Bay is about 12 km. long with northeasterly direction. On the western side of the bay the mountain flank is generally undissected and rises abruptly from the shore, while on the eastern side there is a low foreland, the inland border of which rises to about 120 m. a. s. l. It is somewhat similar to parts of the strandflat along the west coast of Novaya Zemlya. It widens to the south where by degrees it passes into the flat bottom of a valley that strikes in easterly direction and communicates with Notchuyeff Valley. The bottom of the valley is about three km. broad and rises to about 120 m. Between this valley and the Strait is an isolated plateau, Bremerhafen Mts.

The mountains on both sides of the eastern part of the Strait are generally plateaus. The W—E profile along the southern side of the Strait has a striking likeness to that along the southern side of Bessimyanii Fjord rising from 240 m. at the entrance of the Strait to about 600 m. opposite Belushii Bay. The Bremerhafen Plateau and Tchermysheff Plateau have the same elevation as the southern plateau. They seem all to be parts of a greater and once continuous plateau, probably of preglacial origin, remnants of a plain of abrasion or perhaps a peneplain, broadly denuded by a continuous inland ice. The mountain to the west of Belushii Bay, Syernaya Mt., also shows plateau shape seen from the east, but the surface is not at all even, neither here nor on the other plateaus. The previously mentioned foreland cannot be assumed to be a strandflat in the common sense of the word but must be the highest part of a glacier trough, formed by the ice through selective erosion (Pl. XVII, fig. 1).

From Tyouleni Bay (anchorage 11), where ROSMYSLOFF wintered 1768—1769 and the Rosenthal expedition anchored in the summer of 1871, a levelling was carried on in southeasterly direction to the western slope of the Bremerhafen Mts. It was assumed that the range of the tides was 0,75 m. According to the measurement of PAKHTUSSOFF and others this estimation must be somewhat too high, perhaps about 0,25 m., but for the exactness of the levelling this difference is only of secondary importance. Any sea-tang brim was nowhere to be seen east of anchorage 3, and therefore it was necessary to find a value tolerably fit for use.

The locality was favourable for levelling. Hence the measurements are safe within narrow limits. The results were:

1,5 metres, a good shore-line. Drift-wood was found to 16 m. a. s. l..
20,9 „ , a very distinct shore-line on both sides of the bay,
36,2 „ , — — — all around the bay, visible on the opposite side of the Strait to the south.
57,0 „ , a quite good shore-line above a flat beach,
69,0 „ , a shore-line, the measurement somewhat unsafe,
74,5 „ , a somewhat effaced shore-line,
81,3 „ , a very sharp and distinct shore-line both in the locality and at the entrance of the valley running eastwards on the north side,
93,4 „ , a quite good shore-line,
119,8 „ , a very sharp and distinct shore-line, easily pointed out along the sides of the valley to the north,
127,4 „ , a level easily pointed out round a small depression, a former cove close to the mountain side. From here is a relatively steep ascent to
146,6 „ , a very fine shore-line above a broad ledge excavated in rocks and moraine. At
156,6 „ , were uneven ledges in a stony moraine, seemingly no shore-line. At 230—240 m. was a strong block moraine consisting of sandstones and diabase.

At an elevation of 250—260 m. a. s. l. an old river bed crosses the Bremerhafen Plateau from south to north near its western projection.

The moraine ridges on both sides of this channel rise to about 300 m. The channel begins on the southern edge of the plateau 260 m. a. s. l., and the river that once ran through it has cut the moraines vigorously. The river bed (cp. fig. 4) that is about 100 m. wide is covered with masses of water-worn pebbles generally of from pea to nut size. In the southern part some washed moraine heaps are to be seen on the bed. On the northern slope of the plateau the bed fades away in a stony and steep fan or talus. The blocks in the moraine on the sides of the channel consist for the most part of sandstone from the underground rock, but also foreign blocks, especially of divers diabases, were to be seen.

In the great valley between Bremerhafen Plateau and the Rosenthal Mts. there are several lakes drained by a river that runs in westerly direction with its outlet in Tyouleni Bay. One of the lakes is situated close to the east of the bay 52 m. a. s. l. To the north the lake is dammed by an ancient sand barrier, and the lake is therefore an old lagoon. According to the journal of captain MELSOM (20, p. 254) the captain found drift-wood on the shores of the lake.

The river leaves the lake through a canyon cut in the rocks on the western side of the lake near its northern end, and in this channel near the lake the following fossils were found:

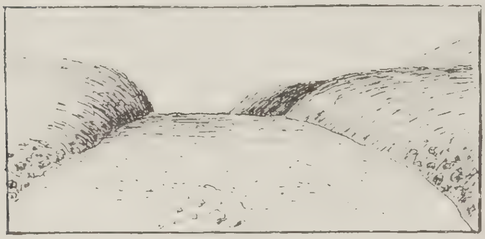
Fig. 4. Sketch of a glacial river bed across the western part of Bremerhafen Mts., seen from the south.

Astarte eliptica, Brown, 1 v.,
Astarte crenata, Gray, var. *inflata*, 1 v. and some fragments,
Astarte borealis, Chemn, fragments,
Cardium grønlandicum, Chemn, fragments,
Mya truncata, Lin, 4 v. and some fragments,
Saxicava arctica, Lin, fragments,
Margarita sp.

Besides the shells plenty of *bryozoa* and *foraminifers* were found.

Along the river above the lake shell fragments were to be seen everywhere. The river bed is about 30—40 m. across, and the banks on both sides were strongly cut by the river. During the thaw in the spring large bodies of water must therefore be transported through the channel. In the summer of 1921 the water body was only small, and the river was easily crossed. About 70 m. a. s. l. 11 v. and 12 fragments of *Saxicava arctica*, Lin, were found.

Between 70 and 80 m. a. s. l. the river runs in a canyon cut in strongly folded rocks. Here no fossils were seen, but there were plenty of erratics of a grey dolomite, green diabases and sandstones. Some of the sandstone blocks were but little pressed, others, however, nearly quartzites.

About 80 m. a. s. l. the river runs on the bottom of a flat depression, and the fossils reappear. Between 80 and 90 m. were gathered:

Astarte eliptica, Brown, 1 v. 15 mm. long,
Mya truncata, Lin, 3 v. and 6 fragments,
Saxicava arctica, Lin, 11 v. and 25 fragments, mostly of a medium size.

Between 90 and 100 m. was plenty of shells. The following species were gathered:

Mya truncata, Lin, 6 v. and 4 fragments,
Saxicava arctica, Lin, 58 v. and 18 fragments. Of the specimens 12 were very thick and 20—30 mm. of lenght. Most of the shells were highly worn by wave action.

Between 100 and 115 m. the occurrence was not quite so monotonous. The following species were found:

Pecten islandicus, Müll, 3 v. and one fragment,
Astarte crenata, Gray, forma typica, 1 v. 12/17,
Macoma calcaria, Chemn, 1 v. 25 mm. of lenght,
Mya truncata, Lin, 4 v. and 6 fragments,
Saxicava arctica, Lin, 7 v. 12—15 mm. of length, 4 very thick,
Balanus sp.

Pebbles of slates, sandstones and quartzites were to be seen everywhere, but only slightly water-worn.

The uppermost occurrence of shells lies between 130 and 142 m. a. s. l. just up to the 146 m. shore-line. The greatest part of the shells was found between 130 and 135 m., but quite uninjured specimens of *Saxicava* were found to 140 m. and fragments of *Mya* and *Saxicava* to 142 m.

The fossiliferous layers are heavily loaded with an overlapping accummulation of sandstone blocks slipped down from the steep rocky slope above.

Here the following species were found:

Pecten islandicus, Müll, 4 v. and 28 fragments,
Astarte borealis, Chemn, 1 v.,
Astarte eliptica, Brown, 4 v., the greatest 15/20,
Astarte montagui, Dellwin 3 v., 6—8 mm. of length, and one fragment,

Mya truncata, Lin, 20 v. and 44 fragments,
Saxicava arctica, Lin, 22 v. and 54 fragments, 7 very thick,
Tectura rubella, Fabr, one specimen,
Balanus sp., 9 fragments.

Besides the shells plenty of spines of echinids, worm tubes, lithotamniæ, and foraminifers were found.

At a river running to the Strait southeast of this locality the following shells were found at the same level, 140 m. a. s.:

Astarte borealis, Chemn, 3 v., the greatest 22/25,
Mya truncata, Lin, var. *uddevalensis*, 10 v. and 11 fragments
Saxicava arctica, Lin, 10 v., three very thick.

This is probably the occurrence mentioned by PEARSON and FEILDEN (56, p. 132).

On the northern side of the valley, north of Bremerhafen Mts., the Rosenthal Mts. rise to about 500 m. To about 105 m. marine sediments were pointed out, containing the following species, gathered at the inner border of the lowland:

Pecten islandicus, Müll, 12 v. and 10 fragments of a medium size
Astarte borealis, Chemn, 1 v. and one fragment,
Astarte eliptica, Brown, 6 v. of a medium size,
Astarte montagui, Dellwin, 8 v., var. *striata* and var. *warhami*,
Mya truncata, Lin, 31 v. and 52 fragments both of the typical form and var. *uddevalensis*,
Saxicava arctica, Lin, 41 v. and 25 fragments,
Balanus sp., 12 fragments.

Besides the shells water-worn pebbles, spines of echinids and plenty of foraminifers were found. The fossiliferous layers lay close up to the mountain slope, and hence they were to some extent overlapped with stones and other debris, weathered from the mountain side.

At an elevation of 320 m. an ice-worn rock ledge, spread with foreign blocks, was observed, and about 350—360 m. an ice-worn saddle carried quite distinct marks that large bodies of running water once forced their way between the edge of a glacier and the mountain side in that level during the melting of the last inland ice, for there were masses of water-worn pebbles and cobbles along the mountain side. On the eastern side of the mountain ridge three moraine terraces were observed at about 460, 450 and 435 m. a. s. l. The terraces were about 100—150 m. wide. These terraces mark stages during the melting of a glacier in a great valley advancing parallel to the Belushii Bay.

The Eastern Entrance of the Strait.

At Cape Poperetschnoi (anchorage 13) a long and broad sand barrier projects into the Strait. As no river discharges itself into the Strait near this place, these accumulations cannot be due to river action in the ordinary way.

To the west of the barrier the depth of the Strait is about 130—135 m., to the east of it, opposite to a large delta built up by a river that descends through a canyon on the south side of the Strait, the depth is only 66—70 m. Farther to the east the depth is again increasing to about 160 m. It is therefore obvious that a ridge above 50 m. high, probably a moraine ridge, crosses the Strait at the delta (Cape Drowjanoi, Wood Cape).

About 1—1,5 km. east of the sand barrier on the northern side of the Strait a levelling was undertaken. The levelling was started to the west of a steep-sided river valley, crossed the valley at some distance from the shore at an elevation of 80 m., and was finished on the unbroken mountain slope facing the Strait east of the valley. The levelling gave the following results:

1,4	metres,	a good shore-line,
12,8	„ ,	an undistinct shore-line on both sides of the Strait. The measurement unsafe.
19,2	„ ,	a shore-line, not good,
34,3	„ ,	a tolerably good shore-line. Can be pointed out on both sides of the Strait. A notch in the mountain profile to the east south of the entrance.
55,8	„ ,	a very sharp and distinct shore-line, especially on the south side of the Strait. A notch in the said mountain profile, the third from the sea.
71,8	„ ,	a distinct shore-line like the former, visible on both sides of the Strait; shells seen.
82,5	„ ,	an indistinct shore-line on the east side of the valley, plenty of shells to 88 m.,
91,0	„ ,	an indistinct shore-line,
112,8	„ ,	a distinct shore-line chiefly on the south side running eastwards with stripes of snow,
146,0	„ ,	a good shore-line on both sides of the Strait. A moraine corresponding with this level is deposited in the valley.

The levelling continued, a higher shore-line was found about 205—206 m. a. s. l. It is strongly engraved in the rocks on the southern side of the Strait from the eastern projection at the entrance to the before mentioned canyon at the Wood Cape. West of this canyon it was not to be seen. In the locality of the levelling the shore-line was not distinct enough to be fixed with certainty, and to the west of the valley it could not be pointed out.

Only a small quantity of shells was found. At 70, 80 and 88 m. the following species was gathered:

Saxicava arctica, Lin, 11 v. and 11 fragments. Plenty of large specimens especially in the 80 m. level.

On both sides of the eastern entrance of the Strait remarkably well developed shore-lines were to be seen, some of which rendered still more distinct by long patches of snow and by notches in the mountain profiles on both sides of the entrance. (Textfig. 5 and pl. IX, fig. 3.) These lines have been observed by several explorers, especially by Roussanoff (67).

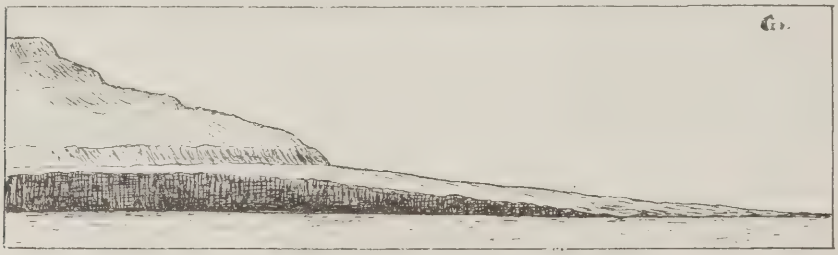

Fig. 5. Sketch of the most eastern promontory on the north side of the eastern entrance of the Strait.

At anchorage 14, east of a river from Nordenskiöld Plateau, a levelling was undertaken. From a distance this locality promised to be favourable, but starting the work it appeared that more shore-lines were so imperfectly developed that a safe determination was quite impossible, and as the Strait is 3—4 km. broad, a determination by aiming across the Strait was not to rely upon.

The following measurements were noted:

1,9	metres,	the top of an embankment enclosing some shallow lagoons. On the embankment and in the lagoons were masses of drift-wood;
19,1	„ ,	a shore-line, faint and difficult to fix,
31,3	„ ,	an effaced shore-line,
53,8	„ ,	a distinct shore-line, but still difficult to fix with safety,
70,8	„ ,	a somewhat effaced shore-line,
100,0	„ ,	the maximum height of the cliff on the north side near the entrance,
111,5	„ ,	a distinct shore-line, but not good in the locality,

117,5 metres, a shore-line below an old cliff,
141,9 „ , a strongly engraved shore-line on the north side of the Strait but difficult to fix in the locality.

From this line a slowly ascending rock surface of slate, only slightly covered with the weathered material of the under-ground rock and with a few patches of gravel and pebbles of foreign origin, leads up to a shore-line 204, 8 m. a. s. l., the uppermost shore-line that can be pointed out. This shore-line is especially distinctly engraved in the above mentioned rock. (Pl. X, fig. 1). It appeared to be developed in the same way on the north side of the entrance of the Strait. Above the shore-line rises a cliff 10—15 m. high that runs along the mountain side westward to the before mentioned canyon, where it disappears. On the north side of the Strait it disappears opposite to this point, just east of anchorage 13. Coincidently with the levelling, DIETRICHSON was engaged in measuring a profile from the sea shore to the plateau above with the tachymeter. He crossed the upper shore-line about 200 m. farther to the east where he found 204,5 m. This accordance between two independent measurings shows a very sharp cut shore-line. Wether the difference of 0,30 m. is due to the gradient of the line cannot be decided, but is to some extent possible.

The plateau above the cliff has an elevation of between 250 and 300 m. It ascends westward with a faint slope.

Summary.

Based on the measurements made along Matotchkin Strait the diagram of the shore-lines of the Strait shown in Pl. XXVII has been drawn. The 215 m. level has only been observed at a single point at the western entrance of the Strait, at the northern projection of Matotchka Mt. A corresponding level has not been observed at the eastern entrance, and therefore it must be concluded that there the land at that time was entirely concealed below the inland ice. The sea had no access to the land, and a shore-line could not engraved.

Between the 215 m. line and the 200 m. line the land must have been continuously rising, for no shore-line has been observed between these levels, but on the western side of the Matotchka Valley outside the terminal moraines a line has been observed 197 m. a. s. l., and on the western side of the Lütke Mts. is a line 198,7 m. a. s. l. The 175 m. level has been pointed out on the eastern side of the pass-valley between Serebryanka Valley and the Strait. Though the elevation of this line has not been determined with any exactness, it can, however, be stated that it is situated between the limits 175 and 190 m., and therefore there can be no doubt of the identity of the line. The recession of the ice along Serebryanka Fjord and Valley, and probably to some extent in the western part of the Strait, was accordingly rather far advanced before the the rise of the land seriously set in. The melting of the ice within the said district must therefore have been due to the easy access of the sea water, and was not followed by an equally quick melting of the ice that covered the mountains inland, for Matotchka Valley was still filled by a glacier, and so were probably the Tchirakina and Choumilika Valleys and to some extent the corresponding parts of the Strait.

At the eastern entrance of the Strait only one shore-line has been observed at an corresponding level, the 204,8 m. line, but this line is, in return, far better engraved than anyone of the above mentioned shore-lines to the west. As it disappears at Wood Cape, the sea at that point, no doubt, once met with an ice cliff which was difficult to force back, as it was the front of a large glacier that filled the greater part of the Strait and Belushii Bay with its head valley and side valleys. The broad ridge across the Strait in this place is consequently a terminal moraine deposited during this resting stage of the ice front. The river bed on the western part of the Bremerhafen Plateau was probably at that time cut by a river which, from the surface of the glacier, entered and crossed the plateau, and disappeared through a sink-hole at the edge of the somewhat smaller glacier in the valley to the north of the plateau.

The ice wall fronting the sea had a height of about 230 m. above the present sea level, that is a height of about 20 m. above the sea level of that time. The thickness of the ice was about 300 m. at the front, 350—400 m. at Cape Syernaya and probably 600—700 m. in the middle part of the Strait, where the depth is 150—160 m. A similar ice front as the one at Wood Cape crossed the Strait to the west at the mouth of the Strait.

The ice wall to the east once broken the ice retired apparently not stopping, till the front had receded to the west of the Baer Valley. Here it came to a standstill for the second time. The western ice front had in all probability been broken earlier than the eastern front. The main glacier receded past the Choumilika Valley probably as far as anchorage 3.

The recession of the ice was followed by a rise of the land, and when the recession ceased, this rise came by degrees to a stop, and a new and relatively strong shore-line was engraved, at 160 m. to the west, at 141 m. at the eastern entrance of the Strait and at about 160 m. at the eastern glacier front. At that time the western part of the Strait was opened from the entrance to the shoals near anchorage 3, from the east of the entrance to Cape Uzkoi between anchorage 6 and anchorage 7. The sand shoals there, like the shoals at anchorage 3, are supposed to have been accumulated in front of a resting glacier, are therefore representing the terminal moraines, as lateral moraines converge against these points. The surface of the glacier, which at that time locked up the Strait, lay about 300 m. above the present sea level.

Several other glaciers entered the opened parts of the Strait. In the Matotchka Valley the ice front lay at the terminal moraines that cross the valley bottom, and the moraine in front on the western side of the valley seems to have been deposited at that time. The Tchirakina and the Choumilika valleys have not been more nearly explored, but as the 160 m. line has not been seen there, it must be assumed that they too were to some extent filled by glaciers. The diverging lateral moraines at the entrance of the Baer Valley show that once a large glacier advanced into the Strait with a fan-shaped lobe which nearly barred the passage. As it is not likely that such a glacier tongue should be left, while the Strait glacier retired past the mouth of the valley, it must be inferred that the glacier had been somewhat reduced at that time, and that this local glacier later on had advanced to the stage marked by the moraines. Farther to the east all the greater valleys may have been partly filled by ice at that time.

During the time of the 160 m. line a rather rich marine fauna lived in the open parts of the Strait, to the west in Pomorskaya Bay, to the east in Belushii Bay. Nearer the front lobes of the presumed Strait glacier, however, no shells have been found at higher level, and therefore a marine fauna cannot have lived there, probably on account of too much fresh water on the surface.

The first shore-line that may be traced all along the Strait lies to the west about 137 m. and to the east 127 m. a. s. l. It is, however, doubtful if the Strait had been opened all over at that time. To judge from the way in which this shore-line occurs, it may be possible that the glacier only had been partly broken into isolated blocks or ice bergs resting on the bottom and with intervening openings and passages.

When the next shore-line, the 121 m. line, was engraved the Strait, however, was certainly opened, and so it has been since that time. Only local glaciers entered the Strait, e. g. a Tretyakoff Glacier much greater than now, and a Chalhonik Glacier that built the moraine across the valley at the upper end of the delta. Fossils have not been observed at this level, probably in part on account of too small salinity of the susface layers in this part of the Strait.

Since that time the land has risen at intervals according to the numerous shore-lines. Shells have been found to 85 m.

Continuous shore-lines have been measured at about 80, 70, 56 and 30 m. Two lines, which along the west coast can be easily pointed out, have not been observed along the Strait, not even at the Tyouleni Bay, a locality better than usually found along the Strait. It seems to be a natural conclusion that the rise of the land at the time of these shore-lines was only suspended to the west, while to the east it went on undisturbed. It is possible that depressions of the land have taken place more or less locally in connection with the forming of shore-lines, but when and where is not easily decided. The only line that seems with certainty to mark the end of a sinking period is the 56 m. line. The observations on which this supposition is founded shall be stated later on.

It is evident from the diagram that the rise of the land as a whole has been greater to the west than to the east, and greater at the middle part of the Strait than at the entrances, but the gradients are small, only between 0,1 and 0,2 m. pro km., that is a good deal less than along the coasts of Norway where the gradients amount to 0,5—1 m. pro km. This fact may be due to the nearness of the center of depression.

3. The West Coast between Serebryanka Fjord and Mashigin Fjord.

Sukhoi Noss.

Mityouchikha Bay to the west of Mityoucheff Mts. is broad and shallow, only about 30 m. according to the Russian charts. To the northwest it is bounded by a peninsula that in the extreme southwest ends in a low prominent foreland called Sukhoi Noss, the Langeness of Barentz. The peninsula, like the peninsulas on both sides of Bessimyannii Fjord, is a remainder of a greater plateau of a medium elevation of 250 to 300 m. at the western edge, and the low promontory is a part of the strandflat.

About 4 km. east of Sukhoi Noss a levelling was undertaken from a break in the cliff, facing the bay just mentioned, in northeasterly direction, with the following results:

2,6 metres, a shore-line, not good. Between 14 and 20 m. wide and even flat,
19,5 „ , an effaced shore-line rather difficult to fix. From this line a flat ascends with a low grade (1—2°) to
64,6 „ , a very distinct shore-line below an ancient cliff 7,5 m. high. At this level a large block of a conglomerate with cobbles of quartzite was noticed.
75,7 „ , a distinct shore-line followed for about 1,5 km.,
82,4 „ , a shore-line visible all around, to the west below a cliff. Above this line was an ancient sand reef 83,5 m. a. s. l.,
84,5 „ , a shore-line somewhat better developed than the former,
87,9 „ , a faintly developed line.

107,9	metres,	a doubtful shore-line. Up to 111,6 m. shells have been found.
115,7	„	, a shore-line rather faint,
141,1	„	, — — —,
156,1	„	, — — —, doubtful,
175,6	„	, a beach,
179,6	„	, a shore-line. The effect of wave action could be traced to about 203 m. a. s. l. From this point the plateau ascended with a slow grade to the east.

The locality was not favourable for levelling, because the large flats made long aims necessary, at times more than 200 m.

The strandflat is broad and flat, especially on the southern side of the peninsula, and worn down by glaciers that once moved forward on both sides of the peninsula. It is therefore covered with a heavy ground-moraine. The cliff that runs to the east from the Noss is continuous for several km. and is generally 10—12 m. high. Near the break in the cliff from which the levelling was started an isolated stack rose from the rocky bottom a few m. from the cliff. On the top of the stack, where the moraine cover had been washed away, several gull families had their breeding place.

Between 70 and 111,6 m. the following shells were found:

Astarte eliptica, Brown, 1 v.,

Astarte montagui, Dellwin, 1 v., size 9/10, var. *striata*,

Mya truncata, Lin, 1 v. and 6 fragments,

Saxicava pholadis, Lin, 6 v. and 17 fragments. Normal size.

It was quite impossible to fix the inner border of the strandflat, but it is assumed to lie about 100 m. a. s. l. The length of the levelled profile was about 4—5 km.

Krestovii Fjord.

The coast between Sukhoi Noss and Krestovii Fjord was only seen from the vessel while passing by, but Krestovii Fjord was subject to a short visit.

On the northern side of the entrance of this fjord a vast remainder of the strandflat stretches westward from the mountains to a low cape for a distance estimated to about 13 km., facing the fjord with an almost continuous cliff (Pl. VII, fig. 3). The strandflat is strongly ice-worn, and low ridges like drumlins run to the west, east of the cape, at some distance from the cliff. The moraine cover is several m. thick but it thins out to 1—0,5 m. against the edge of the cliff. On and within the moraine, masses of erratic blocks and boulders of foreign rocks have been observed, as diabases, quartzites and the like from the central parts of the island. A huge blok more than 10 cub. m., somewhat worn and rounded, of a greenish agglomerate-rock was observed by O. HOLTEDAHL about 20 m. from the edge of the cliff, undoubtedly transported by glacier ice.

A few km. east of the cape there is a small bay with a sand beach between projecting headlands of harder rocks. The bay lies open to the seas and swells from southwest, which wash out the loose material of ground-moraine and fossiliferous marine sediments. These layers seemed to have been deposited in an ancient depression or bay, for the cliffs that face the bay run into these sediments and disappear below them. In another place there was a notch in the cliff of the sketched form showing that once a large mass of rock had been taken away either by wave or ice action, as it were, in a single bit, but this cove, thus formed, has not been filled by sediments as the former one (fig. 6).

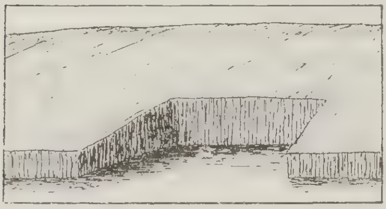

Fig. 6. Sketch showing a break in the cliff on the north side of Krestovii Fjord.

Shore-lines were observed at 10 m. and 18—19 m. Above the 10 m. line cliffs were here and there to be seen, but the 19 m. line had only been washed out in the ground-moraine.

On the southern side of the fjord at a small brook that enters the sea opposite the Wrangel Island a Samoyed settlement is situated. Here the land surface is not developed as an even flat, but is rugged with ice-worn ridges and knolls in the direction of the north-south strike of the district. The ridges do not generally rise above 80—90 m. Between two of these ridges the brook just mentioned runs in northerly direction.

Everywhere is a cover of ground-moraine, especially between the ridges, where a top layer of marine sediments has been deposited. On the rocky ridges were masses of boulders of diabases and quartzites transported by the ice from the east. In the valley on both sides of the said brook shore-lines were easily pointed out at 19, 41—42, 50, 67, and 77 m. a s. l. Many of these lines were distinct and well developed, e. g. the 50 m. line. The measurements were only performed by aneroid, as the place was visited at midnight, and therefore an assistent was not easily obtainable.

Shells were found on the eastern side of the brook between 25 and 67. The species found were:

Astarte borealis, Chemn, 5 v. of dimensions 31/36, 28/33, 26/35, 28/35, 27/32.

Astarte crenata, Gray, 4 v., 19/24, 19/21, 19/22 and 15/17 of a typical form.

Mya truncata, Lin, 2 v. of two specimens, a small and a great one,

Saxicava arctica, Lin, 3 v. 30, 23, and 15 mm. of length.

On the shore the following subfossil and recent species were gathered:

Pecten islandicus, Müll, 9 v., generally small,

Mytilus edulis, Lin, 36 v. and 6 fragments of a normal type and size with periostracum and the valves often connected,

Astarte borealis, Chemn, 3 v.,

Acmæa testudinalis, Müll, 3 specimens of dimensions 15/20, 20/25, and 11/16,

Buccinum undatum, Lin,? 6 specimens of medium size, water worn,

Buccinum grønlandicum, Chemn, one specimen.

Besides the shells also echinids and lithothamniæ bored by Saxicava were found.

To the east of the said ridges the land surface is a fine trough valley whose bottom has been worn down to the level of the sea. Transverse sections generally show nicely rounded and unbroken lines, but at all headlands cliffs were to be seen.

No glacier advances to the head of the fjord, but according to ROUSSANOFF, who accompanied by CANDIOTTI crossed the island from this fjord to Rosmysloff Fjord, there is a continuous glacier along a transverse valley through the entire highland zone (5).

Between Krestovii Fjord and Mashigin Fjord two fjords are situated named by Lütke the South and the North Sulmenyeva Fjord. In the southern fjord two glaciers are to be seen. The one descending from the north advances into the sea with a calving front, but the other from the east seems to stop on the shore enclosed by a moraine. In the northern fjord three glaciers descend. The peninsula between the Sulmenyeva Fjords was, as could be seen, a remainder of a plateau like the peninsulas formerly described.

4. Mashigin Fjord.

(Compare map, pl. 28[1].)

The Outer Basin.

Mashigin Fjord is divided into three parts: The Outer, Middle and Blaafjell Basins. The Outer Basin is at the entrance between Cape Shantz and Point Krouglovsky 10 km. broad, but the width is increasing to about 12—14 km. farther inwards. The length is about 18 km. The inlet or sound to the Middle Basin is two km. wide between the isolated mountains, Mt. Nansen to the south and Mt. Tveten to the north of the sound. At the time when the land was submerged to more than 100 m. below the present sea level, these mountains were islands. At present both the southern and the northern inlet have been raised above sea level, and only the middle inlet still remains.

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[1] Note by Prof. HOLTEDAHL: After my 'Brief Account' with Dietrichsons map of the Mashigin Fjord was published (in 1922) I have learnt that the 3 large glaciers at the eastern part of the Mashigin Fjord have already been named by Roussanoff in a small skale sketch map, of which, in May 1923, I saw a manuscript copy in the paleontological department of the Museum Nat. d'Histoire Naturelle in Paris

To the southwest of Cape Shantz the land has an abrupt descent to the sea, forming rich rockeries, but east of the Cape the southern side of the Basin has an undulating surface ascending with a low grade to the south and southeast where this lowland passes into the lowland north of the North Sulmenyeva Fjord. The cliffs are inconspicuous and mostly confined to the western sides of the points.

On the north side of the Outer Basin a broad foreland intervenes between the sea shore and the mountain slope behind that leads up to a plateau, which farthest to the west, Weber Ridge, has an elevation of 210—220 m. but rises with an even slope to the northeast.

The western part of the foreland or strandflat is about 3—4 km. wide, but the width increases to the east, 5 km. from Point Krouglovsky, to about 8 km. From this point to Mt. Tveten are 5 small bays between headlands of harder rocks, diabase. Some of these headlands or points look from a distance like long prominent piers. Within these bays cliffs are only seen along the sides of the headlands, for at the heads of the bays there are sand beaches, as generally loose material is washed out. The inner border of the strandflat rises to about 120 m.

The Outer Basin has a relatively even bottom. At the entrance of the bay the depth is about 36 m. and somewhat off the outer coast line 130 m. according to the English Admiralty Chart. About 5 km. from the entrance a series of soundings carried out by our expedition from Sol Bay in southwesterly direction to Nemak Bay, showed an even increase of the depth, from 7 m. at the head of Sol Bay and 36 m. at the entrance of the bay. The maximum depth 140 m. was fallen in with near the entrance of Nemak Bay. A single sounding farther to the east states 139 m., and a sounding at the inlet to the Middle Basin shows a depth of 124 m. The Outer Basin, therefore, is probably a flat bottomed trough, and as the lead very seldom took up loose material, it must be concluded that there for the most part is rocky bottom. The Outer Basin thus seems to be a rock basin.

(where Roussanoffs collections are kept) and which also has been printed in an official report on Novaya Zemlya of 1910, edited by Mr. Sosnovsky, at that time governor of Arkhangel. As there can be no doubt as to which glaciers Roussanoff's names are meant for, the correct thing is to introduce his names: Plan, Boule, and Lacroix Glaciers in Dietrichsons map.

Only the north side of that part of the fjord was somewhat more closely surveyed. A levelling from Rækved Bay to Weber Ridge gave the following result:

2,9 metres, a shore-line. Masses of drift-wood, both trunks and roots, marked by axe and saw. At 7 m. an ancient root without any mark of tools.
13,0 „ , a shore-line, not easily fixed. The edge of the cliff had an elevation of 21,9 m. in that place, and from there an even and horizontal flat stretches towards a little valley running east-west. On the sides of the valley, at
31,0 „ , a shore-line is easily pointed out, but not quite so easily fixed. On the northern side of the brook the land surface ascends from the valley floor with a low grade to
42,2 „ , a safe and good shore-line. Shells observed.
52,2 „ , a distinct shore-line, a main level here. Shells observed.
61,3 „ , a faintly developed shore-line.
68,8 „ , a good shore-line.
76,5 „ , — — —
81,5 „ , a shore-line not easily fixed. From there a stony undulating ground to
99,5 „ , a good shore-line. Probably the high tide level measured.
111,9 „ , a slightly engraved but safe shore-line.
117,9 „ , a shore-line. The measurement not safe.
132,3 „ , a safe level, but not easily fixed.
150,6 „ , a flat beach.
156,2 „ , the corresponding shore-line, distinct.
171,3 „ , a shore-line, not distinct.

At 213,2 the levelling was given up on account of fog. Here a large block of a devonian coral was found, transported from the central zone by the ice.

From the point where the levelling was given up, a plateau stretches eastwards, but it is not at all even, or for any greater part a plain. Finely rounded pebbles were numerous between 215 and 218 m. where the plateau had been washed by the sea. A sample of the soil was taken, containing shell fragments. The underground rock was a slate only slightly weathered after the marine abrasion.

Above this marine level the loose material was inconsiderable, but a multitude of foreign blocks and boulders of conglomerates, sandstones, and quartzites were spread all over the rock surface.

Sol Bay between Point Spirifer and Point Muren is divided through Point Lava in an eastern part with a pocket beach at the head and a western part where the land rises steeply from a narrow sand beach. In this western part is a favourable anchorage with a depth of 7 m. From the western beach a gate leads through Point Lava to the eastern beach. Close to the east of the gate is the outlet of a river that runs in a narrow channel, an old canyon. In this valley patches of marine sediments were seen to about 50 m. a. s. l., and in these sediments the following shells were gathered:

Astarte borealis, Chemn, more specimens and fragments. Three of the valves had the dimensions 18/22, 24/30 and 24/32.

Mya truncata, Lin, 7 fragments of the ordinary type.

The right side of the valley is the steepest, and there, as a rule, the marine sediments have been washed away, but the fossils were still found on that side of the river, and as the material was stratified, it probably cannot have settled on the spot after a slide from above. Both the 42 and 50 m. lines were to be seen on the sides of the valley, the 52 m. line, however, was somewhat faint. The channel has been cut in the bottom of an ancient valley with rather slowly rising sides, and on these slopes the 62 m. could be easily pointed out. The 69 m. line was, on the contrary, rather faint.

According to the observations mentioned above there is reason to believe that the channel had been cut before the 52 m. line was engraved, and the channel may have been cut above a base level not much higher than the present sea level. Then the land was submerged to the 52 m. line, and the channel was filled by marine deposits that later on have mostly been washed away during the last rise of the land. It must be noted that above the 52 m. line the river course is broad and ripe, and all the loose material has been washed away by the river down to the rocky surface or the hard packed ground-moraine.

Below the 52 m. shore-line the ancient channel has been so strongly blocked up in some places that the river has not yet been able to wash away the filling, and is therefore compelled to cut a new channel past the blocked spot. Near the outlet the river has cut a new channel through the ridge that advances into the sea as Point Lava, because the old bed was so heavily blocked up that the river could not recover its former bed. In some places, where the river had reached the old bottom of the channel, it has depeened its bed about 2 m. after the reopening of the gorge.

On the beach east of Point Lava masses of drift-wood have been washed ashore, for the most part old trunks, but also recent things, viz. boards, beams of all dimensions, a piece of birchen cord-wood with bark all round, the only birchen piece of drift-wood seen in Novaya Zemlya by our expedition. The recent things did not reach higher than 4 m., but in the bed of a brook an old and somewhat rotten trunk was found partly embedded in marine deposits 21 m. a. s. l. The wood had very thick circles.

The eastern part of Sol Bay is on both sides bordered by cliffs, but at the head of the bay only loose material has been observed. The cliffs seems to disappear into these deposits (Pl. XIV, fig. 1). Shore-lines have been observed at 3, 13, 21, 30 and 52 m. The last level surrounds a small knoll of igneous rocks.

Earth-flow is a general phenomenon on all slopes on the northern side of Mashigin Fjord. If the surface is even and only grades in one direction, stripes 1—2 m. wide run down the slope parted by narrow water-kennels often paved with stones. To these rills most of the vegetation sticks, no doubt on account of the moisture, but the paving may often consist of so big stones or otherwise be of so coarse a material that plants do not thrive, and then the kennels are barren. If the land surface is convex, the stripes diverge, but in a cup-shaped depression they converge towards the bottom of the depression, sometimes swelling to tongue-shaped earth fullers, if there is plenty of water and a steep descent.

It is noteworthy that despite of the flow of the soil all shore-lines engraved in loose material are apparently not the least destructed. From this fact it must be inferred that the earth-flow in Novaya Zemlya is a surface phenomenon only active during the thaw in the spring, when the surface layers have thawn but to a minute depth.

East of the valley just mentioned between 30 and 50 m. the following shells were found:

Astarte borealis, Chemn, 35 v., the two greatest with the dimensions 33/38 and 20/26,
Astarte crenata, Gray, 1 v. 25/29,
Astarte montagui, Dellwin, var. *warhami*, 4 v. between 9/12 and 14/18 and 2 fragments,
Macoma calcaria, Chemn, 1 v., a great specimen,
Mya truncata, Lin, 3 v. and one fragment of the typical form,
Saxicava pholadis, Lin, 6 v. and 2 fragments.

On the shore R. Lund found:

Mytilus edulis, Lin, 1 v. 28/50,
Astarte borealis, Chemn, one specimen with cohesive valves, 25/32. These shells had been recently washed ashore.

The low foreland is very broad and rises so slowly that a levelling could not be performed. The medium gradient is presumably about 1/60.

About 6 km. east of Sol Bay is the wide Dal Bay, so called because a flat and ice-worn valley, the Viking Valley, stretches from the head of the bay to the north instead of the strandflat. Mt. Golovin bounds the bay to the east, and to the west it is bounded by the eastern border of the foreland or strandflat whose width here is considerably reduced. From Point Sætre the land surface rises with a moderate grade towards the Diabase Mts. Shore-lines have been pointed out at 53, 63, 82, 102, 114, and 118 m. a. s. l. (aneroid).

At 100 m. the following shells were found:

Astarte borealis, Chemn, 4 v. 32/37, 26/30, 28/33 and 25/30.

Mya truncata, Lin, 1 v.,

Saxicava arctica, Lin, 1 v. and 2 fragments.

Higher situated shore-lines were found at 138, 158—159, and 218 m., the last mentioned line above a conspicuous rock ledge.

Between Mt. Golovin and Mt. Tveten is a fourth bay, called Straumsnes Bay, about 2,5 km. wide and 3,5 km. long. The mountain sides rise abruptly from the shores on both sides of the bay, but at the head is a large delta in front of a glacier advancing from the north and bordered to the east by the moraines of Plan Glacier. The bay is the submerged part of a broad valley strongly excavated by a glacier from the east, the united lobes of Plan Glacier and the glacier from the north (Pl. XIV, fig. 3).

On the steeply ascending mountain side to the west of the bay shore-lines have been pointed out at 3, 13,5 and 62—63 m. a. s. l. A 53 m. line was not to be seen, but shore-lines at 70—71, 77, 83 m. were distinct and easily fixed, and so was a shore-line 104 m. a. s. l. below a weathered cliff. A line at 113 m. could not be pointed out with certainty. Higher shore-lines were observed at 120, 136, 151, 162, 171—172 m. The uppermost marine level noticed is situated at an elevation of 218—219 m. Above this line no trace of wave action was to be seen. All these lines have been pointed out on the western side of a narrow valley, and besides the shore-lines there is a cirque facing the bay. A small glacier or a great snow drift now covers a part of the bottom of the cirque at about 180—190 m.

On the eastern side of the said valley huge blocks and boulders are to be seen everywhere.

The delta has been built by the rivers from Plan Glacier and the said glacier from the north. Plan Glacier faces both the bay and the Middle Basin. Both ice lobes are enclosed by continuous moraines. The rivers were too swollen to be crossed, but by the aid of the field glass it was easily stated that at least the two lowest shore-lines were engraved in the moraines of Plan Glacier. On the northern side of the delta the 71 m. line is distinct. A moraine deposited by a small cirque glacier covers a ledge in this level, and is therefore younger than the shore-line. A small river running from this glacier has cut a narrow channel 2,5 m. deep in the phyllitic schist after the time of the 52 m. line.

Fram Bay and Lynge Glacier.

(Cp. pl. II, fig. 1.)

The Fram Bay to the west of Mt. Nansen is quite small and with a large delta ascending to about 5 m. at the head. From the inner border of the delta plain rises the steep front of a glacier, called Lynge Glacier. The imposing hills and ridges surrounding the glacier tongue consist but apparently of morainic material. The fact is that the greater part is stone-ice buried below a relatively thin cover of moraine, more or less overgrown with a scanty vegetation of high-arctic plants. In the moraine cover shore-lines have been traced to about 84 m. a. s. l. To this level the overgrown moraine prevails, but higher several ridges of a younger moraine bound the visible part of the glacier tongue. The ice is blue coloured and dense without crevasses and fissures, and the melting water derived from the ablation runs in narrow channels on the surface of the ice. In one place a great water body came to the surface through a couple of holes in the ice, visible by great bubbles, and from there a river runs on a bed of ice to the base of the moraines.

From the younger moraines an ancient river bed could be followed across the older moraine down to a fan on the outer slope about 55 m. a. s. l. At 33 m. a shore-line crosses the fan, stating that the fan has been washed by the sea. The fan is presumably built when the level of the sea stood 52 m. higher than now.

In front of the moraine is an isolated moraine ridge, running from the north towards the river. On the western slope of this ridge 10 m. a. s. l. a top layer of morainic material, 1 m. thick and overgrown with grasses and creeping bushes *(Salix glauca)*, slipped down, because it rested on solid ice that melted away on account of the exceptionally warm weather in these days of August 1921. It must therefore be inferred that this ridge too consisted of stone-ice with a comparatively thin moraine cover. The slides that took place elsewhere along the front of the moraines showed indeed that the moraine cover was not thick enough to protect the ice against melting on the steep slopes, if only the rays of the sun have an opportunity of working continuously for a few days. Moraine ridges of this kind are very common in Novaya Zemlya as will be repeatedly stated (Pl. XIII, fig. 1).

Mount Nansen and the Southern Side of the Middle Basin.

Mt. Nansen is the isolated mountain between Fram Bay and the inlet to the Middle Basin. The sharp weathered ridge runs in northeasterly direction and rises probably to about 900 m., an exceptional elevation so near the outer coast line. The rock in the upper levels is a peculiar and easily recognizable agglomerate (volcanic breccia) of green colour. The mountain was climbed from the eastern shore of Fram Bay, but the highest peak was not reached. Farther to the north the western side is a high and unaccessible cliff. To the south of the cliff shore-lines were observed at 13, 20 and 43 m. a. s. l. These lines were relatively faintly developed on the slowly ascending slope. The 54 m. line was distinct below a low bluff, but shore-lines at 63, 71, 84, and 102 were faint. At an elevation of 163 and 218 m. were strongly engraved shore-lines. From here the ascent was very steep. At 310 m. was a rock ledge, at 320 m. a similar ledge, and at 340 m. a line running to the south along the mountain side. A sample of the soil was taken, but no traces of organisms have been found.

On the east side of the mountain ridge a hanging glacier, which has not yet formed a true cirque, faces the east between 700 and 140 m. a. s. l. Based on these figures the elevation of the snowline may be computed by taking the arithmetic mean as follows: $\frac{760 + 140}{2} = 450$ m. The lower part of the glacier is bordered by huge moraine masses, for the greater part consisting of rocks transported by a large glacier from the east. Shore-lines at 54, 63, 84, and 120 m. can be traced on this ancient moraine that is now overgrown with vegetation. But a younger moraine consisting of the green agglomerate from Mt. Nansen has later on been built upon this old foundation. Two parts or ridges can be distinguished in the younger moraine, a lower part consisting of blocks with a reddish brown weathered surface and a higher part, the blocks of which had conserved their original freshness. There must therefore have been two older stages during the time Mt. Nansen glacier has existed. The present stage is the third one (Pl. XVII, fig. 1).

In the valley east of Mt. Nansen an isolated dolomite crag rises to about 265 m. a. s. l. From the shore of Storli Harbour to the top of the crag shore-lines have been observed at the following heights: 14—15, a faint line above a fine flat, 23 m., a faint line, 35 m., a line easily fixed, 43 m., a distinct line. A 53 m. line is strongly engraved in moraine material, a 84 m. line is good, and at 101 m. and 113 m. are faint lines. From here an even flat rises to 121 m. where there is a very distinct shore-line easily fixed. Here the following shells were found:

Astarte borealis, Chemn, 20 v. and 3 fragments of great specimens,
Mya truncata, Lin, 2 v. and 9 fragments,
Saxicava pholadis, Lin, 1 v.

Between the northern end of the outcropping dolomite and the sea shore the ridge only consists of morainic material. From the 121 m. line the ascent is steep, and the moraine is lacking or scanty. At 164 m. is an eroded level, and at 220 m. there is a distinct limit between weathered material and material washed by the sea. At 242 m. is a moraine level, but no shore-line.

On the western slope of the crag a huge block of the green agglomerate was observed 115 m. a. s. l., estimated to 20 cubic m., and on the northeastern slope 80 m. a. s. l. a still greater block of the same rock was found, estimated to 100 cub. m. These blocks were not in the least ice-worn and may have been transported from Mt. Nansen by floating ice.

East of the dolomite crag a glacier advances to the sea called the Økland Glacier. The lower half of the glacier tongue is surrounded by steep walls dipping from the glacier, in some places quite inaccessible, 50—70 m. high. The wall to the west is more than one km. of length, and as this wall was much exposed to the rays of the sun the melting of the ice caused frequent slides on the steep slope (Pl. XII, fig. 2). The moraine was broken by the sea at the most projecting point of the glacier tongue, and there the ice was exposed to the attack of the sea water (Pl. XVII, fig. 1).

The moraine cover is thick, especially at the front of the glacier, so that the underlying ice is there protected against melting. The old moraine cover is grown over with vegetation.

The east side of the glacier is steep too, but as that side was less exposed to the sun no melting and slipping had taken place. The vegetation had nowhere been spoiled, and the wall could in some places be mounted. No uncovered ice was here to be seen.

The visible part of the glacier tongue is on both sides surmounted by moraine covered ice ridges about 10—12 m. high (Pl. XII, fig. 3). This moraine cover is a younger moraine, consisting for the greater part of blocks and boulders arranged in two nearly separate ridges.

Both on the old moraine and in the younger material on the ice ridges shell fragments and valves have been found between 40 and 85 m. a. s. l.:

Mya truncata, Lin, 4 v. and 4 fragments among which one hinge,
Saxicava pholadis, Lin, 2 umbos and 90 fragments,
Balanus sp.

Ancient shore-lines could be pointed out about 14, 22—23, 33, and 42—43 m. a. s. l. both on the old overgrown moraine and on the younger barren one. The 84 m. and 102 m. shore-lines were to be seen only on the ancient moraine.

The valley between the glacier and Mt. Grønlie is deep and relatively narrow. On its eastern side the levels 102 and 122 m. were represented by lines and small terraces in the loose material.

The North Side of the Middle Basin.

On the northern side of the Middle Basin from a bay close to the east of Mt. Tveten, called Blomster Bay, a levelling was carried out from the eastern shore of the bay to the top of a crag or ridge similar to the crag mentioned above on the southern side of the basin. More shore-lines were distinctly developed around the southern end of the ridge, a place that always has been open to the swell from the west.

The results of the levelling are follows:

3,6	metres,	a shore-line,
14,5	„ ,	a faint shore-line, the measurement therefore unsafe,
26,0	„ ,	a shore-line, visible in the distance but not to be fixed on the spot,
43,1	„ ,	a distinct shore-line,
53,7	„ ,	— —
84,8	„ ,	an excellent shore-line in the locality,
103,5	„ ,	a faint shore-line on a slowly ascending slope,
113,2	„ ,	— — — —
120,9	„ ,	a very sharp and distinct shore-line, easily fixed below a low bluff. From here the ascent was rather steep,
135,1	„ ,	a rock ledge,
141,2	„ ,	a rock ledge. A notch in the southern end of Mt. Tveten.
163,8	„ ,	a very good shore-line,
171,7	„ ,	a faint level on the ridge. A notch in Mt. Tveten.
191,0	„ ,	the top of the ridge.

On the eastern slope below the 120,9 m. line were terrace-steps and shore-lines 72, and 63 m. a. s. l. The 54 m. line was distinct above a flat between the ridge and the terminal moraine of Plan Glacier. This flat seemed to have been washed by the sea after the last advance of the glacier. Below the 121 m. line the rock ridge was replaced by a ridge of moraine material running down to the sea shore.

Plan Glacier advances broad and imposing through a valley between rounded mountains out upon the flatter foreland. The eastern flank of the glacier tongue rises with a steep wall from the barren ground and the lake Trehørningen. The rest of the front is bordered by a ring of moraine, and ascends more slowly with an even curve towards the inner surface.

Some slipping was observed along the eastern wall, but, after all, slipping must be rare, as the morainic material accumulated at the base of the wall was quite inconsiderable. Some parts of the moraine had a scanty cover of vegetation.

Lake Trehørningen is drained by a river that runs along the moraine covered eastern wall of the glacier with a rather steep bed. The lake lies about 60 m. a. s. l. surrounded by a shore-line at 63 m. North of the lake more distinct shore-lines were to be seen up to 120 m., but they have not been measured. Somewhat farther to the east two large ridges cross the foreland, assumed to be moraines (moraine covered ridges of stone ice) as they run in southeasterly direction in an acute angle to the strike. Fossils were seen in several places of the common arctic species to about 100 m.

Between the foreland here and the 3—4 km. long vertical calving front of Lacroix Glacier leads a narrow passage, 5—6 m. deep, from the Middle Basin into the Blaafjell Basin.

Lacroix Glacier.

The front of this glacier is 15—20 metres high (Pl. X, fig. 3). To the left is a deep and narrow valley between the opposite mountain side and the glacier, and here the moraine at the base of the glacier is not large. On the opposite side of this valley a terrace has been engraved in moraine material along the mountain slope 140 m. a. s. l.

The lowest part of the glacier tongue has a slow ascent, but about 300 m. from the front the ascent grows suddenly steep with long and deep crevasses across (Pl. XXII, fig. 2). Above this zone of crevasses the ascent once more decreases and only small fissures are to be seen.

On the right side of the glacier both an ancient overgrown moraine and a younger moraine of blocks and boulders can be pointed out. The ancient moraine forms rounded hills to a height of about 370 m. From this point the small Junior Glacier parts from the main glacier and advances to the shore opposite Blaafjell Island, enclosed by a moraine ridge.

The younger moraine appears at a height of 400 m. and curves along the edge of the glacier. The ridge or ridges consist mostly of ice with a thin cover of gravel and boulders of various size, for the most part perfectly rounded and scratched. Along the inner side of the ridge runs a river through a channel of stone ice without fissures, paved by cobbles and pebbles. In the moraine to the right of this channel an old river bed could be followed for some hundred m. There can be no doubt that the lateral part of the glacier with the moraine cover does not join in the motion of the rest of the glacier. On the surface of the central part of the glacier rounded water worn cobbles and pebbles were now and then to be seen, indicating that the glacier in some places or others has access to such ancient material.

The younger moraine fronts the Blaafjell Basin to the west of a delta, farther to the west forming a point bent to the left into the sound between the basins. It seems to have been washed by the sea to about 25 m., and at 15 m. a. s. l. a distinct shore-line has been engraved on the front side of the projecting point (Pl. XII, fig. 1). This part of the moraine consequently is not quite so young as might be thought at first, and the lateral, moraine-covered part of the ice front has therefore been "dead" ice for a long time in spite of a relatively quick motion of the rest of the front close by.

From the shore south-west of Blaafjell Island a levelling was undertaken. The results were as follow:

2,8	metres,	a shore-line, quite distinct,
14,8	„ ,	an exceptionally distinct shore-line all around Blaafjell Basin,
32,0	„ ,	a shore-line, not distinct. Visible in the young moraine.
37,6	„ ,	an effaced shore-line. Safe fixing not possible.
54,2	„ ,	a distinct shore-line strongly engraved and easily fixed. Not to be pointed out in the younger moraine.
72,0	„ ,	a shore-line, not distinct.
83,2	„ ,	a shore-line not quite distinct, but visible on both side of the basin.
95,0	„ ,	a doubtful line,
101,7	„ ,	a good shore-line easily pointed out on both sides of the basin.
116,5	„ ,	an effaced level not to be safely fixed.
121,4	„ ,	a distinct shore-line on both sides of the fjord. Here the levelling was given up, as the ground seemed to be too unfavourable. At 165 m., however, a distinct shore-line could be pointed out by aneroid.

Blaafjell Glacier.

On the southern side of Blaafjell Basin is a large delta in front of a glacier, called Blaafjell Glacier. The delta rises to about 10 m. a. s. l. at the base of the moraines. To judge from terraces seen here and there on the delta, it is obvious that the delta once had been built up to a higher level, corresponding to the 15 m. shore-line. Nowadays these terraces are washed away by the rivers eroding down to the present base level (Pl. XV, fig. 2). The moraines ascend abruptly from the delta and a valley to the north, and are quite unaccessible except in one place where a river has cut its way to the plain. No river emerges under the ice at the base of the moraine, and but inconsiderable masses of morainic material, slipped down from above, are accumulated there. The river just mentioned emerges from a cave in blue and dense ice without fissures about 125 m. a. s. l. and runs in a channel excavated in the ice and paved with cobbles and boulders (Pl. XV, fig. 3.) The moraine cover is rather thin. Near the front wall of the moraine covered glacier tongue the river runs below a bluff of ice to the left, which shows curving and nearly vertically arranged stripes on the wall, presumably owing to horizontal pressure.

Along the edge of the front wall a multitude of huge boulders lay on or were embedded in a clayey matrix that here and there was about to slip out. Slipping must, however, very seldom take place and only in an insignificant scale, judging from the relatively small masses of moraine material accumulated at the base. The greater slipping on the day of my visit must therefore be due to the exceptionally warm weather during this and the preceding days. In one place on the northeastern side of the moraine a slip had exposed the ice, and there the morainic cover was seen to be only about one metre. The great moraine-like accumulation here in front of the visible ice therefore consists of ice with only a thin cover of morainic material as elsewhere on Mashigin Fjord. The walls are, for that reason, also much steeper than the slopes of ordinary moraines or other loose ground.

Where no slipping has taken place the ancient moraine cover is overgrown by vegetation. The ice cave from which the glacier river emerges lies about 115 m. above the base of the glacier front. The river crosses a depression, before it cuts the frontal ridge, and its water was almost clear. The uncovered glacier ice was met with at about 135 m. a. s. l. enclosed by two moraine ridges, built upon the ancient stone ice and partly overlapping the older moraine. From 135 m. to 160 m. shell fragments were found on these ridges in a loose gravelly material looking like ordinary sand-mixed gravel from the sea shore.

The surface of the ice lies much lower than the enclosing moraines. No crevasses or fissures were to be seen, and the water derived from the ablation ran in channels 1—1,5 m. deep down the relatively steep frontal part of the glacier to sinkholes at the moraines. This part of the surface was well washed and even. In a single spot, however, a heap of fossiliferous gravel lay on the ice 163 m. a. s. l., three km. from the outer border of the delta (Pl. XIII, fig. 2).

Of the following species shells were found:

Astarte borealis, Chemn, one fragment, somewhat doubtful determination.

Mya truncata, Lin, 2 v. and 11 fragments,

Saxicava arctica, Lin, 2 v. and 5 fragments.

To the left of the glacier tongue a ridge runs inwards in southeasterly direction from the terminal moraine. From a distance this ridge looks like a true moraine ridge, but it consists for the greater part of ice, and the moraine cover was so thin that melting took place almost everywhere. A wandering along the ridge was therefore very troublesome on account of the water-socked mud. The ridge ends about 225 m. a. s. l., at the level of the uppermost marine shore-line around the inner part of Mashigin Fjord (Pl. XIV, fig. 2).

This glacier, which now must be assumed to be "dead", has once cut a deep gorge with quite perpendicular walls in the floor of an ancient ice-eroded saddle. The old ice-worn bottom cuts the walls at nearly right angles along a sharp edge.

The North Side of Blaafjell Basin.

On the northern side of Blaafjell Basin is a foreland with a relatively slow ascent between the sea shore and the steep mountain slope behind. The inner border of the lowland lies 120—130 m. a. s. l. The 2,8 m. and the 15 m. lines are perfectly developed and they look rather recent. The 15 m. line forms a sharply defined limit of vegetation. The lower land looks grey and monotonous compared with the land above which is more perfectly overgrown.

The 21 m. line is faintly developed above small flats, but is, however, easily pointed out. A 33—34 m. line is distinct above a large flat, and so is the 54 m. line too. Also a 57 m. line could be pointed out. The 72 m. line is good and the 102 m. line is distinctly engraved in a fan deposited at that time by a brook. Higher up shore-lines have been observed at 122, 166, 202 and 220 m. a. s. l. along the mountain sides above the lowland. All these shore-lines are more or less distinct or at least visible all along the slopes enclosing the Blaafjell Basin. The lines have been measured by aneroid and controlled by help of the levelling instrument.

Boule Glacier.

At the head of Blaafjell Basin is the front of Boule Glacier. For a short distance the front is calving. The eastern part lies on the land along a river that drains a lake (lake Tora) to the east. Some hundred m. ahead of the glacier, on both sides of the fjord, the lateral remains of an ancient terminal moraine project, washed and somewhat levelled by the sea. All the lower shore-lines before mentioned have been engraved in these moraines.

On the northern moraine shells were found in several places. The species:

Pecten islandicus, Müll, 2 v. and 7 fragments,
Mya truncata, Lin, 2 v. and 10 fragments,

Saxicava pholadis, Lin, 1 v. and 20 fragments were found on the top of the ridge 90 m. a. s. l. On the inner side of the moraine up to 90 m. have been further found:

Astarte borealis, Chemn, 1 v. and 3 fragments,
Cardium grønlandicum, Chemn, 1 v. and one fragment,
Macoma calcaria, Chemn, 1 v. and one fragment,
Mya truncata, Lin, 1 v. and 8 fragments,
Saxicava arctica, Lin, 1 v. and 5 fragments.

The uppermost level washed by the sea lies 125 m. above the present shore-line. The 102 m. line seemed to be the uppermost shore-line inside the moraine. Two advances of the glacier seemed to have taken place, the one at the time of the 54 m. line during which the inner slope of the moraine had been somewhat ploughed for a short distance, the other at the time of the 15 m. line, marked by small sand heaps. Behind these sand heaps the 15 m. line cannot be pointed out. The front of the glacier was then about 200 m. farther advanced than now. The 3 m. line can be traced on some small sand ridges close to the present glacier front (Pl. XV, fig. 1).

Whether the ancient moraines consist of ice or morainic matter cannot be decided, as they are overgrown by vegetation all over, and no slips had taken place, but it must be assumed that they do not make any exception to the rule noticed in these regions. Such huge accumulations of loose material have never been observed elsewhere in Novaya Zemlya.

From Blaafjell Basin to Zivolka Fjord.

(Cp. pl. XXIX.)

On the 31th of July professor HOLTEDAHL started his ice wandering from Mashigin Fjord to Zivolka Fjord on the east coast, accompanied by TVETEN and R. HOLTEDAHL[1]. The author of this paper was also one of the party for the first 10—12 km. The glacier was mounted close to the east of the small sand ridges above mentioned. The ascent was at first rather steep with some transverse crevasses, none so great, however, that the crossing was seriously obstructed. In one place a stony moraine cropped out and made its way on the surface of the ice to the front, forming a dark stripe, but else the surface was quite free from stones or other loose material. About 12 km. from the starting point a nunatak rises about 400 m. above the ice to 880 m. a. s. l. The top of the nunatak was well rounded and ice-worn and partly covered by snow or firn ice. From the top was a splendid view of a strongly glaciated landscape with isolated tops jutting out of the ice, the southwestern mountain of the Trollheimen Mt. group of the map. Above the 450 m. level the ice always surrounded the tops or ridges with a concave surface, but below this line the surface is generally convex. From 400 m. upwards the surface of the glacier was partly covered by new fallen snow, and from an elevation of 450 m. the surface was dry and solid and easily passable (Pl. XVI, fig. 1). Below the 400 m. line, on the contrary, numerous ponds were to be crossed or outflanked. This fact suggest that the snowline in this latitude must be situated between 400 and 500 m. or more nearly fixed at 450 m. as previously stated. This determination may therefore be nearly correct.

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[1] Cp. HOLTEDAHL's report "A Crossing of Novaya Zemlya", Geogr. Journ., vol. LIX, 1922, p. 370.

According to HOLTEDAHL the main ice divide on the "central ice plateau" lies about 20 km. from Mashigin Fjord 350 m. a. s. l. From this divide the Foggy Glacier goes to the southwest ending with huge moraines to the east of the Lake Tora. To the east the Ibis Glacier goes to the Zivolka Fjord. Near the right side of this glacier a middle moraine ridge runs from the Pakhtusov Mt. to the front, that is for a distance of 20 km. (Pl. XVI, fig. 2). The lower part of this ridge has formerly been described by PEARSON and FEILDEN, who visited Zivolka Fjord 1897. Near the front of Ibis Glacier shells were found on the ice. About 15 m. a. s. l. O. HOLTEDAHL gathered the following species on the sloping ice surface:

Astarte borealis, Chemn, 1 v. and 2 fragments,
Mya truncata, Lin, 5 fragments,
Saxicava arctica, Lin, 4 fragments,
Balanus sp., one fragment.

At the head of the fjord there was plenty of drift-wood. The following shells were found 30 m. a. s. l.:

Pecten islandicus, Mull, 2 v. and 5 fragments,
Mya truncata, Lin, 2 v. of common size,
Saxicava arctica, Lin, 3 v. 35, 28, and 20 mm. of length and
Saxicava pholadis, Lin, 1 v. 18/39.

Somewhat to the east of the median line of the Ibis glacier about 150 m. a. s. l., HOLTEDAHL observed a small isolated dark mass on the ice (fig. 7), at a distance looking like a small heap of moraine material. When investigated the heap proved to be a little knoll of ice with a thin cover (generally less than 1 dm. thick) of a rather fine-grained gravel, with very wellrounded pebbles, the latter being without any doubt water-worn. This thin cover of gravel evidently has protected the underlying ice from melting, causing the ice to stand up in a knoll. It is of great interest that according to the observations of FEILDEN (see 56 pp. 149—150), the moraine to the west to a large extent contained well rounded pebbles: "threequartes of its stones, large and small, were much water-worn". "The only explanation appeared to be, that the remains of some ancient beach was being carried down to the sea, mixed with debris of rocks from the mountain protruding through the glacier" (Pakhtusov Mt.). In the locality noticed by HOLTEDAHL, there was, however, no moranic material at all.

The mountains on both sides of the Middle Basin and the Blaafjell Basin rise to a considerable height. Mt. Dietrichson to the north of the Blaafjell Basin is 946 m., Mt. Reidar to the south of the basin 780 m., Mt. Grønlie 730 m., and Mt. Nansen probably near 900 m. The previously mentioned nunatak in the Trollheimen Mt. group is 880 m. high and more nunataks farther to the east are undoubtedly of the same elevation or higher (Pl. XVI, fig. 3). The mountains are as a rule more or less isolated by valleys and saddles which are, or once have been, filled by glaciers, and their summits have been rounded by ice action. They must therefore long ago have been covered by an ice sheet, but since then they have been nunataks for a long time. A level of old lateral moraine terraces can be pointed out in some places about 700 m. a. s. l. In the central part of the island at the latitude of Mashigin Fjord the mountains are completely surrounded by glaciers, at the heads of the fjords they are only partly surrounded, and a few rise from environs free from ice. The great elevation of the mountains

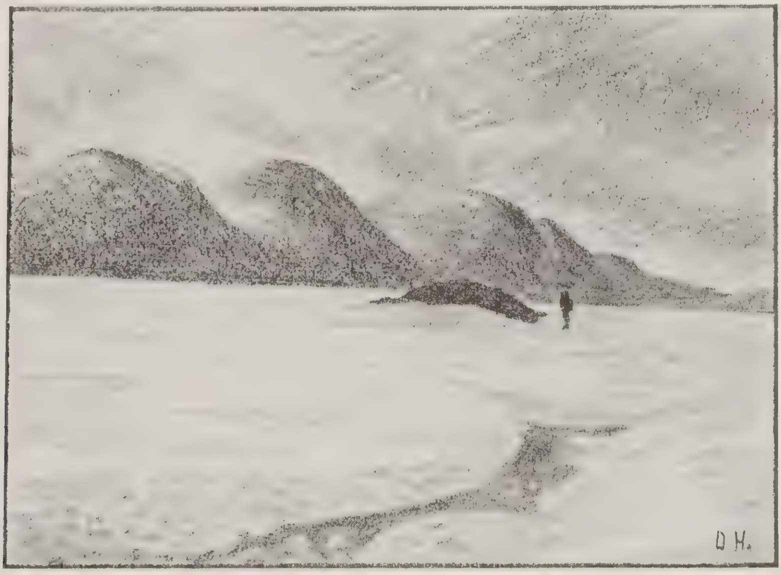

Fig. 7. From the Ibis Glacier, with an isolated mass of water-worn gravel on the ice. The nicely ice-eroded mountains are made up of clay slate. To the right the Zivolka Fjord. Drawn by O. HOLTEDAHL from a photograph.

just mentioned is due to the fact that they consist of the metamorphic rocks of the "central zones" (cp. HOLTEDAHL's paper on the rock formations this report no. 22). The peninsulas between the fjords, made up of weaker rocks, are much lower and less dissected, not rising above 500—600 m.

Summary.

According to the observations which have been made and the facts that have been collected, an ice sheet thick enough to conceal even the highest mountain tops once covered the land. Later on Mashigin Fjord was filled by a large glacier with its front at the entrance of the Outer Basin, which much be assumed to be a rock basin excavated by this glacier. The basin is generally 120—130 m. deep, and the deepest part is 140 m., but at the entrance the depth does not exceed 36 m. Any considerable silting up by deposition of moraine material was hardly possible as the current along the coast would take off the finer deposits successively, and the supply of blocks and boulders must have been diminutive as lateral moraines or traces of terminal moraines on land have not been pointed out at the entrance of the fjord. Such coarse material does not seem to have been transported by the glacier during that stage to any greater extent.

The thickness of this glacier cannot be estimated with certainty, but may not have surpassed 300—400 m. above the present sea level in the Outer Basin. The glacier communicated with a Sulmenyeva Glacier through the low passage between the basin and this fjord, and it is probable that a greater part of the peninsula between these fjords was covered by the ice.

It is likely that the land at that time was quite considerably submerged, presumably to 350 m. or more. The lines on the western side of Mt. Nansen seem to suggest a submergence to that amount after the melting of the ice in the Outer Basin, but it must be admitted that those lines are not yet proved to be sure shore-lines. The higher land north of the basin has not been explored closely enough to give an answer to this question. The suggested level corresponds fairly well to the high levels between Bessimyannii Fjord and Gribovii Fjord, assumed to be ancient marine levels.

While the land was submerged to the uppermost safe shore-line, ascending from about 218 m. at the mouth to 225 m. on the inner part of the fjord, the ice front crossed the inlet to the Middle Basin, and a more southern part of the front crossed the valley south of Mt. Nansen. The top of this ice front lay about 240—250 m. above the present sea level with an elevation of about 20—30 m. above the sea according to the lateral moraine terrace on the dolomite ridge. This stage of the ice front may be contemporaneous with that stage of the great Matotchkin

Glacier when the front crossed the Strait from the northern projection of Mt. Matotchka, west of Pomorskaya Bay. At that time a glacier filled Straumsnes Bay with its front at the entrance, and it is likely that a glacier filled the Viking Valley too.

The glacier that filled the Middle and Blaafjell Basins was of course supplied through the same passages by which the present ice fields of the inland are drained. As the supply of the main glacier gradually decreased during the melting period, the time must arrive when the motion came to an end, and after that date all the tributary glaciers, which still happened to be moving, might stop against a "dead" ice wall and by degrees come to rest as peculiar lobes separated from the main glacier by a cover of moraine and heavely loaded with morainic debris. They may have been literally buried in their own moraine material and the river deposits that the melt water rivers spread upon them. On account of the great submergence the sea water would press forward along the flanks of the main glacier, praying upon the clean and motionless body of stone ice, till at last it parted into isolated ice bergs that floated away. The ancient tributaries, on the contrary, which were protected by their cover of moraine and river deposits endured a submergence below the sea level and have held their ground to this day. The Blaafjell Glacier was such a tributary glacier brought to a stop against the flank of a dead glacier mass in the basin. The vertical lines or bands of pressure of the front of this moraine-covered dead glacier and the occurrences of large boulders on the top of the steep frontal wall are easily explained in that way. The shells which were found in the younger moraine and on isolated heaps on the ice to 163 m. a. s. l. suggest that the old glacier not only was buried below moraine and river deposits, but that the glacier once has been drowned below the sea surface allowing mollusks to immigrate and settle in the loose material above the underground ice. It is not likely that the mollusks lived in the place where the shells are now to be found; they may have been transported for some distance during a later advance of the glacier from near the 225 m. line.

The 225 m. line cannot be traced to the east of the above mentioned delta, neither on the same side nor on the opposite side of Blaafjell Basin. The main glacier, therefore, seems to have filled the basin to the east of the delta, while the ice in the other parts of the fjord had melted away or at any rate had been much reduced. The Lacroix Glacier was probably forced back beyond its present stage, possibly beyond the break in its bed before mentioned. At the present time the frontal part of this glacier is believed to rest upon the sea bottom of that time.

When the land had risen to the 122 m. line the front of Boule Glacier lay at the moraines 700 m. in advance of the present front, for the moraines have been levelled by wave action at that level. It is, however, probable that the front of this glacier was nearly stationary during the uplift of the land from the 225 m. level to the 122 m. level, as it is likely that this glacier too was buried below a cover of loose materials accumulated by the stationary melting on the surface at the moraines.

To what extent the melting of the inland ice took place, as the land continued to rise, cannot be decided, but the existence of the many shore-lines shows that the weight of the ice has not decreased continuously. A stop of the melting may have reacted on the movement of the land surface quite at once so near the centre of the ice load.

There is reason to believe that the dead glaciers originally were larger, and that they have been reduced by melting on the surface especially while submerged.

5. **The West Coast between Cape Borisoff and the Pankratyeff Peninsula.**

The Strandflat Northeast of Cape Borisoff.

Cape Borisoff is a low promontory belonging to the strandflat which from the Cape runs in northeasterly direction for about 5 km. Farther to the northeast the land rises abruptly from the sea shore to the plateau. The foreland or strandflat here is similar to the lowland along the northern side of the Outer Basin, but there is a difference, however, because there exist at the northwestern border of the flat near the sea shore several elongated ridges, drumlins, and farther to the southwest and near the mountain side there are terminal moraines (Pl. XIX, fig. 1). Behind these moraines a round knoll has been observed, either a rocky hill covered by moraine or an ice knoll with a moraine cover too thick to allow the ice to be seen.

The greater part of the flat lies below 20 m. and is fine and even. Shore-lines have been measured at 12, 29, 42 and 50 m. The 42 m. and the 50 m. lines were engraved in the moraine. Near the mountain side a 70 m. level and a 81—82 m. level were good. A 99 m. level was distinct with a number of erratic blocks of sandstone, diabases, and quartzites. Shore-lines were traceable at 110 and 118 m., and on the steep mountain slope levels at 140—142 and near 160 m. could be pointed out. Above the 160 m. line was an old cliff. Higher up the slope the ascent was so steep that climbing was only possible by following the dry bed of a water course where the outcropping rock layers gave foothold. The rock was a dark slate.

Drift-wood was found to 10 m. a. s. l. (Pl. XIX, fig. 3) and shells between 80 and 95 m. The following species were gathered:

Mya truncata, Lin, 10 v. and 4 fragments,
Saxicava pholadis, Lin, 2 v. and 20 fragments.

At the head of the bay to the northeast of Cape Borisoff there is a glacier on a socle which from the distance was estimated to be about 80—100 m. high, and to the north of this glacier another glacier tongue is advancing nearer to the sea level but is not calving.

The Admiralty Peninsula.

To the north of the bay just mentioned a lowland projects far to the west. It is the Admiralty Peninsula, formerly an island according to BARENTZ and LÜTKE. The shallow and impassable sound that hundred years ago separated the island and the mainland is at present silted up either by sediments deposited by glacier rivers, or has been laid dry by the uplift of the land. It is, however, most probable that both these agents have been working together. At present the former sound is replaced by a low neck of land bordered to the east by the front of a large glacier. The northern part of the front of this glacier advances into Glassova Bay north of the peninsula with a continuous cliff, from which a steady calving took place in the last days of August 1921. Where the front crosses the neck it is enclosed by a moraine, and so is the case with the greatest part of the southeastern front, which is only calving for a short distance.

The glacier covers a great part of the low foreland and is supplied by 4 tributaries, which make their way from the interior to the lowland through saddle-shaped valleys or notches in the edge of the plateau land. The glacier, therefore, belongs to the Piedmont type, a glacier type not observed farther to the south. The notches through which the tributaries advance have very steep sides, and the flanks cut an ancient ice-worn rock surface at an obtuse angle, something like 120—150 degrees.

Round Admiralty Peninsula runs a rather broad strandflat that forms the projecting headlands. The higher land, as far as it has been observed, is ice-worn all over, and all tops and ridges have been rounded by ice action. The western edge of the plateau is rounded everywhere.

From the southern shore of Glassova Bay a levelling was undertaken. Shore-lines were observed at the following heights above sea level:

3,0 metres, a shore-line below a low cliff,
11,0 „ , — — — above a broad terrace flat below a cliff 7,3 metres high,
21,0 „ , a shore-line, quite faint,
33,3 „ , a faint shore-line,

42,3 metres, a faint shore-line,
50,1 „ , a somewhat better engraved shore-line,
61,6 „ , an effaced shore-line. Two small drumlins were observed 68 metres above sea level.
70,0 „ , a quite good shore-line,
79,0 „ , — — — — —
100,0 „ , a shore-line. Up to this level the loose material was a hard-packed ground-moraine or till, and no traces of fossils were to be seen.
114,1 „ , a very good shore-line.
120,8 „ , a very distinct line, easily pointed out.
133,4 „ , a shore-line,
142,6 „ , — — — with a rock ledge. The top of a cairn at 156,5 metres above sea level.
164,7 „ , a good shore-line above a broad flat. Another flat at 168 metres.
172,2 „ , a shore-line with a multitude of water-worn pebbles. At an elevation of 183 m. a. s. l. the levelling was given up, as no higher knolls or crags were to be seen near at hand. Scarcely any part of the peninsula, therefore, rises above 200 m. above the level of the sea. It has once been submerged below the sea surface, for well rounded pebbles were everywhere to be seen. The outcropping rock was generally a dark phyllitic slate. On the hill where the levelling was given up a sandstone layer cropped out dipping nearly vertically.

Mytilus edulis, Lin, was seen to a height of about 10 m., but beyond that shells were not seen while levelling. DIETRICHSON found the following species about 115 m. a. s. l.:

Astarte borealis, Chemn, 3 v. of dimensions 24/29, 23/27, and 21/29.
Astarte crenata, Gray, 2 v. of dimensions 21/24, 21,5/25,
Mya truncata, Lin, 6 v. and 9 fragments of great specimens,
Saxicava pholadis, Lin, 9 v. from 31/36 to 13/37, and some fragments.

On the flat below the 11 m. line the depth of the thawed soil above the frozen underground was found to be 0,86 m. in the last days of August. The material at the bottom of the digging was a tenacious clay without fossils of any kind.

The Admiralty Peninsula is an isolated part of the plateau land separated from the mainland by the action of the ice and the glacier rivers. The minor elevation is partly owing to its great distance from the central zone of the mountain range, partly to the action of the ice sheet that once overflowed the land.

North of the calving glacier front in Glassova Bay the coast is for a short distance relatively steep, because the low foreland is insignificant or lacking. Farther to the north the coast line is once more hidden below an ice cover, and a continuous calving ice front stretches for about 15—20 km. towards Nordenskiöld Bay.

A strandflat has not been observed between Nordenskiöld Bay and Arkhangel Bay, and the mountains seem to rise abruptly from a steep cliff coast. Five glaciers enter the sea through notches or valleys cut in the western edge of the lateral plateau.

It is likely that all these glaciers at the time of the great Mashigin glacier united to a continuous piedmont glacier. Where the supplies were greatest and the motion a maximum, a presumed strandflat would be worn down below the present level of the sea. To the east of Admiralty Peninsula the motion of the ice was checked by the high island, and therefore the strandflat is there preserved.

Opposite to the southern promontory of William Island the northmost one of the before mentioned 5 glaciers enters the sea from northeast with a long calving front from which small ice bergs at intervals float away. North of this glacier the coast is steep with fowling cliffs towards the entrance of Arkhangel Bay.

Arkhangel Bay.

Arkhangel Bay is situated between the mainland to the southeast and two islands, Berkh Island and Litchutin Island, to the northwest. At the head of the bay a river running through an ice-worn valley with northwesterly direction enters the bay.

To the west of this valley a rock ridge runs in the same direction, and along this ridge a levelling was undertaken from the shore of the bay. The series of shore-lines known from levellings farther to the south were found at the following heights above sea level:

3,2	metres,	a shore-line,
11,7	„ ,	a distinct shore-line,
23,3	„ ,	a faintly developed shore-line,
36,0	„ ,	a strongly engraved shore-line, easily pointed out on the slope of the valley,
48,9	„ ,	a good shore-line,
58,8	„ ,	a quite good shore-line. Easily pointed out on the east slope of the valley, and on the southern side of Litchutin Island.

66,0	metres,	a shore-line, good.
73,1	„	, a faint shore-line,
78,5	„	, a strongly engraved shore-line seen on the eastern slope of the valley, running close below a steep wall.
90,0	„	, a shore-line,
106,9	„	, a shore-line somewhat difficult to fix.
127,2	„	, a very good shore-line. Shells found.
145,3	„	, a shore-line,
169,5	„	, a good shore-line,
186,9	„	, a shore-line,
203.2	„	, a shore-line and a fine rock ledge.
238,9	„	, a good shore-line below a weathered cliff. In this level is the uppermost occurrence of shells (Pl. XIX, fig. 2).

The levelling was given up at an elevation of 271,8 m. at the inner border of a flat with a multitude of water-worn pebbles. Similar levels were found at 295 and 305 m. above the sea. These levels have been pointed out both on the side of the ridge that faces the valley and on the southwestern slope. Rounded pebbles are to be found everywhere, but at the uppermost levels they are much weathered and grown over with lichens or shivered through the frost. There can be no doubt that these levels are of marine origin, for they are facing the sea in an open situation.

At the southern end of the ridge the 272 m. level was represented by a great flat levelled by the sea at the head of an ancient cove, and to the west is a flat valley opening upon Arkhangel Bay. At the head of the valley some terraces have been observed, 315 and 322 m. a. s. l. These terraces appear only locally, and therefore they may have been formed in an ice dammed lake at the border of a glacier traversing the lower part of the valley.

To the west of the terraces just mentioned on the slowly ascending western slope of the valley or basin, a terminal moraine has been pointed out, consisting for the most part of boulders of a grey conglomerate. On the western front of the moraine the 272 m. level was engraved. At the base of the moraine was a little lake, drained by a brook at the northeastern corner, 230 m. a. s. l. Close to the outlet of the brook and up to the moraine, shells have been found 5 m. above the level of the lake, 235 m. above the level of the sea. The species found was

Saxicava arctica, Lin, 1 v. and 9 fragments of at least 4 specimens. The locality lies 3—4 km. west of the above mentioned ridge.

To the north of the outlet of the brook the 240 m. level was engraved all around an isolated knoll, which consists of moraine, or is a rocky crag with a thick moraine cover. At about 250 m. the top of the knoll was levelled by wave action, and the flat was spread all over with water-worn pebbles, especially on the northern side of the flat. It is probable that a greater part of the pebbles originates from the grey conglomerate.

On carrying out the above mentioned levelling shells were found at more levels above the sea:

At 40—50 metres:

Saxicava pholadis, Lin, 3 v. 19/38, 17/38, and 18/35,

Saxicava arctica, Lin, 1 v. 14 24.

At 110—118 metres:

Pecten islandicus Müll, one fragment,

Mya truncata, Lin, 2 v. and 6 fragments,

Saxicava arctica, Lin, 4 v. and 38 fragments.

At 120 metres:

Mya truncata, Lin, 3 v. and 8 fragments. Besides the shells some fine-rounded pebbles were seen.

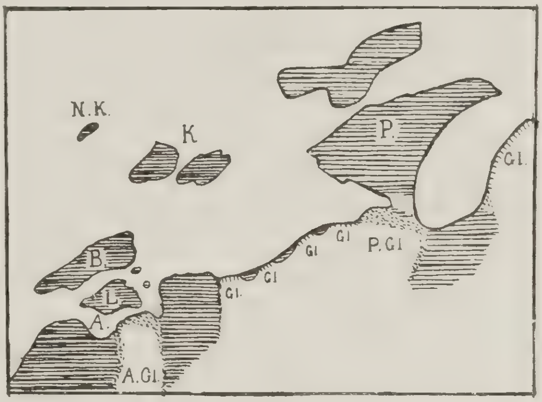

Fig. 8. The coast region Arkhangel Bay (A) — Pankratyeff Peninsula (P). A. Gl. = Arkhangel Glacier, Gl. = glaciers with calving fronts, P. Gl. = Pankratyeff Glacier, L. = Litchutin Island, B. = Berkh Isl., K. = Eastern Krestovii Islands, N. K. = Northern Krestovii Isl.

At 140—150 metres:

Mya truncata, Lin, 1 v. and 16 fragments,

Saxicava arctica, Lin, 5 v. from 15/27 to 11 20, and some fragments.

At 157 metres:

Saxicava arctica, Lin, 4 fragments.

At 172 metres:

Astarte borealis, Chemn, a doubtfull fragment,

Saxicava arctica, Lin, 1 v. of dimensions 10/20, and 6 fragments.

At 182 metres:

Saxicava arctica, Lin, 1 v. and 2 fragments.

At 192 metres:

Saxicava arctica, Lin, 3 small fragments;

At 238,9 metres:

Saxicava arctica, Lin, 2 small fragments.

Besides the shells some water-worn pebbles were gathered. The shell fragments found at 192 and 238,9 m. have been difficult to determine. A possible mistake of *Saxicava* for *Mya* is thinkable, but on account of the character of these ancient deposits such a mistake is not at all probable, and would at all events be of no consequence.

The upper part of the valley east of the ridge on which these shells have been found is occupied by a small local glacier between 60 and 300 m. a. s. l. The glacier is rather thin. To the east it is bounded by a rock ridge. On the western side of this ridge, a few m. above the border of the glacier, is a rock ledge with a beach of cobbles and pebbles 200 m. above the sea, and here 4 fragments of *Saxicava arctica*, Lin, were found, between 195 and 200 m. At the bottom of the valley below the glacier, shells of the common arctic species have been observed in several places. In the past the glacier seems to have made two advances. During the first advance the ice filled the valley on a level with the flanking ridges. The advance was followed by a sinking of the land possibly to the 58 m. shore-line, and the glacier had a calving front in the sea. During the last advance the glacier was not large enough to cover the bottom of the valley, and therefore the glacier tongue was bordered by elongated lateral moraine ridges, especially to the west, but as the land was more elevated than during the former advance, the shore-line lying between 23 and 36 m. higher than now; the tongue apparently advanced farther down the valley.

Gorboff Islands.

Litchutin Island on the northern side of Arkhangel Bay has an elevation of about 220 m. All the levelled shore-lines can be pointed out, often represented by excellent flats and beaches below ancient cliffs. The island is traversed by two ridges parallel to the strike of the rock layers, the one (to the N.W.) running along the sound that separates the island from Berkh Island to the west, the other farther to the southeast. These ridges form headlands to the north, and at the head of the bay between the headlands is a fine flat ascending slowly to 22 m. On this flat is plenty of drift-wood of all dimensions. To about 10 m. pieces of wood marked by axe have been observed.

Round this ancient bay the 35 m. line is distinctly engraved, and so is the case with the 80 m. line. The 145 m. line, the 165 m. line and the 202 m. line are distinct with fine beaches and ledges along the eastern slope of the ridge first mentioned. The top of the island is obviously water-worn.

At 100 m. a. s. l. the following shells were found:

Mya truncata, Lin, 6 v, and 8 fragments,
Saxicava arctica, Lin, 3 fragments, and at
60 metres:
Astarte borealis, Chemn, 1 v. 37/40 with periostracum,

Cardium grønlandicum, Chemn. 2 v. and 7 fragments,
Mya truncata, Lin, 3 fragments.

East of the inner ridge is a small lake, drained to Arkhangel Bay, 70 m. a. s. l. Round the lake the 77 m. line was distinctly engraved, and close below this shore-line pieces of wood have been found embedded in sand layers. It is, however, probable that these pieces have been used for a fox trap by hunters, and now is in a secondary place. No drift-wood in a sure primary place has else been observed at so great an elevation above the sea.

To the east Litchutin Island is separated from the mainland by a narrow sound. According to LÜTKE and SPÖRER this sound was formerly an usable passage between Arkhangel Bay and the fine and calm bay north of the island. At present the sound is shallow and practically impassable even to rowing-boats, and the said bay that is an excellent anchorage, is only accessible from the northwest.

Along the eastern side of the sound runs the front of a large glacier. The front is calving for a short distance in Arkhangel Bay, but along the sound the glacier has a moraine covered frontal lobe, which stretches for about one km. farther to the north where there is a great delta plain in front of the glacier. Sandy deposits transported by the glacier streams have undoubtedly silted up the sound between the mainland and the island, yet it is probable that the rise of the land has been the most essential cause (Pl. XXIV, fig. 1).

A small islet in the northwestern part of the northern bay has on the east side a flat and fine sand beach, where masses of drift-wood have been washed on shore. 4,5 m. a. s. l. lay a log, at 7 m. a weathered end of a batten with an iron nail, besides a tusk of a walrus. Above the 11 m. shore-line was a cliff. Birch bark was seen to above 10 m. upon sliding soil.

Berkh Island to the N.W. of Litchutin I. is 6—7 km. long and about one km. broad. The southeastern side is very steep with high cliffs, but the northwestern side that faces the open sea ascends with a slower grade from the sea shore to about 120 m. This part of the island, therefore, is a sort of strandflat though not at all even. The island rises to 150—160 m., and at the higher levels masses of blocks and boulders of the mainland rocks are seen everywhere.

Along the western shore plenty of drift-wood has been washed ashore, both modern and ancient things. 6 m. above sea level a weathered mast head was found. At 7—8 m. was a level especially rich in drift-wood, for the greater part trunks with appendant roots, at a single place partly covered below a great snow-drift. A similar level was to be seen 17—18 m. above the sea, where a multitude of partly rotten trunks lay half-way buried in the sand. Of more interest was a find of a log, 3 m. of lenght and 10 cm. in diameter, with a distinct mark of an axe 20 m. a. s. l., and a similar log, without such marks, at 22 m. These logs lay on a slowly ascending flat. A find in the same level was made in a rock cleft or defile between a prominent crag and an isolated stack. The bottom of the cleft lay 18 m. a. s. l., and at 22 m. three logs were found washed up between some sharp-edged blocks at the base of the stack. Two of them were logs with roots, but the third had been cut down by an axe. A transverse section shows 189 annual circles, some of which are only about 0,2 mm. thick. Professor JENS HOLMBOE who has had a piece of the log for determination was inclined to suppose it to be of larch (or perhaps of spruce); a closer determination was impossible.

The logs found in the 22 m. level must be in the primary place where once they were washed ashore, for hunters would not amuse themselves by aimlesly carrying drift-wood to places of no use to them. One km. farther to the north in the middle of the island, 120 m. a. s. l., rods of drift-wood have been found, but there the rods have obviously been used for tent poles, and in other places pieces of drift-wood have been used as material for fox traps.

While the 22 m. line was engraved, or just subsequent to that time, there seems to have been an active drift period. The west coast must have been free from ice for a long time. The drift-wood may have come from Russia, for all the modern things washed ashore on the west coast of Novaya Zemlya are of European origin, such as glass floats of several types found to about 7 m., beams, planks etc. The logs in question must, on account on the small circles, have grown slowly under unfavourable climatic conditions. The axe, which has been used on the marked logs, must have had a sharp steel edge.

Before the last half of the seventeenth century saws were not common in Europe (65), and all wood cut by saw must therefore be of a younger date. No such wood has been found higher than 7 m. a. s. l., not even in places open to the full force of the seas. The rise of the land cannot, therefore, have been considerable during the last centuries. Above the 22 m. level drift-wood has not been observed in primary place on Berkh Island.

On the western slope shells and baleens of whales were found 60 m. above the sea. On the eastern side of the island on a wide rock ledge shells were found in two levels.

At 50 metres:

Mya truncata, Lin, 1 v. and 2 fragments, thick shelled but of common type,

Saxicava arctica, Lin, 17 v. and 8 fragments with dimensions between 28/32 and 18/19. Only uncommonly thick-shelled specimens of a medium size were seen. Besides these species a very thick shelled specimen of

Astarte eliptica, Brown, of dimensions 20 22 with effaced ribbing, and a fragment of a

Buccinum sp. were found.

At 60 metres:

Saxicava arctica, Lin, 70 v. of the same type as above mentioned,
Balanus sp., two fragments.

The find was made by ØKLAND. The shells lay on the surface in great masses.

The Krestovii or Cross Islands.

These islands, their number being 3, are situated to the north and northeast of Berkh Island. They are quite low, the northernmost one not above 11 m. This island is long and narrow. Masses of drift-wood are to be seen everywhere. To about 5 m. sawn timber of every kind has been found, but above this level the wood consists mostly of older things, often marked by axe but never by saw.

The outcropping rock layers (Permo-Carboniferous sandstones etc.) have nearly vertical dip. Many erratic blocks and boulders derived from the central mainland area (sandstones, dolomites, a green diabase) were to be seen. A block with a Devonian coral (according to the determination of HOLTEDAHL) was also found.

The shells that were found looked recent. The following species have been collected:

Pecten islandicus, Müll, 1 v.
Mya truncata, Lin, 4 v. and 5 fragments,
Saxicava arctica, Lin, 4 v. and 5 fragments,
Buccinum undatum, Lin, ? one specimen. Besides the shells lithothamniæ, fragments and teeth of Echinus etc. were common.

Farther to the southeast, nearer to the coast of the mainland, lie the two other, much larger and higher islands. The one nearest the coast was visited by the expedition. At the lower levels was plenty of drift-wood, both weathered and fresh, especially on the eastern side, but small pieces were observed up to the 22 m. line. Glass floats were found to 3,5 m., and wan timber to 4 m. a. s. l. Five m. above the sea lay a jaw of a whale 5 m. long and nearly straight. At 10 m. a good many bones and antlers of reindeer and bones of ice bear and smaller animals were observed.

About 30 m. a. s. l. were several small and shallow lakelets, and around these the ground was so firm that no foot-prints were left.

Arkhangel Glacier.

As before mentioned is the front of the large glacier east of the sound that separates Litchutin Island from the mainland for the greater part enclosed by moraines, and is only calving for a short distance (Pl. XXIV, fig. 1). The left border or southern side of the glacier has only been seen from the distance. The right border, on the contrary, has been followed for a distance of 8—10 km. across the foreland to the point where the glacier leaves the saddle or notch through which it passes from the inland area. This northern flank of the glacier is only sparingly covered with moraine material and rises rather abruptly from the lowland, crossing ridges and valleys on its way.

All the shore-lines from the 65 m. line upwards seem to disappear beneath the ice at nearly a right angle (Pl. XX, fig. 1), and therefore these shore-lines must be older than the present glacier. The lower shore-lines from the 11 m. line to the 36 m. line can be traced along the front of the glacier, and they are of course younger than the moraine in which they have been engraved. Also the 48 m. line seemed to be engraved in the moraine, but this observation is not safe. As for the 56 m. line it was quite impossible to get sure observations, as the frontal part of the glacier at that level consisted of ice without a moraine cover, and the flank was too steep to keep lasting traces of a former shore-line, even if such a line once had existed. The 56 m. line is otherwise quite distinctly engraved for a long distance to the north of the glacier, in some places with a well developed cliff (Pl. XX, fig. 2). Below this level the glacier river has cut a rather deep gorge, through which the greater part of the melting water from the glacier runs down to the sea, building the above mentioned delta plain ahead of the outlet. No streams have been observed emerging at the base of the glacier tongue.

It must be noted that only a small amount of morainic matter is to be seen along the base of the northern flank. The greater part of the morainic material covers the front and the ridges of ice along the flanking slopes. At the point where the glacier enters the foreland, the ice wall that faces the mountain side is quite clean, and there is no moraine material on the top of the wall. At the base of the glacier the limit between the ice and the ground-moraine is very distinct. Only small blocks and boulders are to be seen along the water course (Pl. XXI, fig. 1).

On the surface of the glacier were no blocks, only heaps of a dark gravel were here and there to be seen. No crevasses cut the ice, and the melting-water streams run in channels on the surface for long distances (Pl. XXII, fig. 1), not immerging till they reach the bordering ridges, or not immerging at all. These ridges rise somewhat above the inner surface, and their moraine cover is quite thin with relatively small blocks and boulders.

The motion of that glacier must be quite inconsiderable, and, with exception of the central part which enters Arkhangel Bay, it must be considered a "dead" glacier, for the greater part consisting of stone ice.

Near the base of the northern side of the glacier shells have been found at the following levels:

At 63 m.:

Astarte borealis, Chemn, three fragments,
Mya truncate, Lin, three small fragments.

At 145—160 m.:

Saxicava pholadis, Lin, 1 v. and five fragments. These shells were found about 8 km. from the bay, the perfect valve 150 m. a. s. l.

In morainic material on the glacier near the northern border, 130 m. a. s. l. the following species were found:

Astarte borealis, Chemn, one fragment,
Saxicava arctica, Lin, 8 fragments.

The part of the glacier that rests on the foreland has only a small elevation above sea level. Where the glacier steps out from the inner land, the surface of the ice does not rise above 250 m. At that point near the northern border of the glacier is a rounded knoll on which ledges have been observed 210, 275, and 320 m. a. s. l. These ledges may be strand-marks engraved by the sea during a former submergence of the land. The lower part of the knoll is seen on pl. XXI, fig. 1 to the left, and a part of the rock surface near the summit is seen on pl. XXIV, fig. 3.

The Pankratyeff Peninsula.

Between Arkhangel Bay and the Pankratyeff Peninsula the greater part of the foreland is covered by glaciers that enter the sea with more or less developed calving fronts (Pl. XVII, fig. 3). Above one half of the coast line is ice cliffs. The foreland does not rise higher than 160—170 m.

The Pankratyeff Peninsula is by a neck of sand and gravel connected with the mainland (Pl. XXIII, fig. 1). On the shores of the bay south of the connecting neck masses of drift-wood were to be seen at lower levels. The bay is entered by a large glacier. The southern part of the front forms a vertical calving wall, but the rest of the border of the glacier, both to the west against the bay and to the north, seems to have lost its ability of moving, and consists of stone ice with a frontal moraine cover. Only in a part of the northern flank near the point where the glacier enters the foreland has the glacier some motion still. Here the ice wall slides out for a short distance in northwesterly direction.

Along the northern flank of the glacier a lateral river makes its way to a bay to the north of the gravel bank that connects the peninsula to the mainland. Another glacier stream enters the bay to the south of the bank. This river, which is for the most part supplied through water courses on the surface, has built a small delta plain. From the inner border of the delta rises a bluff consisting of a bottom layer of a clayey moraine overlapped by a thick top layer of washed and sorted sand. From 20 m. a. s. l. the sand deposits are in their broad features arranged in heaps and series parallel to the ice border.

By levelling the following shore-lines have been found:

3,3 metres, a shore-line at the inner border of the delta, very good and distinct,

11,1 „ , a shore-line above a little flat. In this level were masses of drift-wood. 12 m. above the sea was a piece of wood with a piercing iron nail of an ancient hand-forged type. The find was made on the east-facing slope of a sand ridge in which shallow furrows ran inwards against the ice front. At 17,2 m. masses of drift-wood were seen.

26,0 „ , a shore-line. To 23 m. drift-wood was observed.

36,7 „ , — — —. In this level was a small horizontal flat with some vegetation.

48,5 „ , a shore-line. At an elevation of 52 m. a number of small hilloks or heaps of washed sand and gravel were arranged parallel to the visible ice border (Pl. XXIII, fig. 2), but heaps of that type are, however, met with to above 60 m. Accumulations of loose material with such a *licked* surface have only been observed at the front of Boule Glacier near the present sea level (Pl. XV, fig. 1). These sand ridges have undoubtedly been washed by the sea, and therefore the similar ridges on the Pankratyeff Glacier are presumed to have been washed in the same way, though no shore-line could be traced above them.

In the channel cut by the river could be clearly seen that the sand layers topped a clayey moraine which in some places is ruffled and folded, as if it has been pushed forward. Just above the 3,3 m. line at the head of the delta this old moraine is about 5 m. thick and seems to be untouched, and the horizontal sand layers are 2—3 m. thick, but at higher levels the sand appears in ridges parallel to the ice front covering the rubbed ancient moraine. The moraine is often washed out in blocks rolled and rounded by the running water to cobbles and pebbles of a quaternary conglomerate.

It seems quite obvious that the glacier once made its way into the ancient moraine, which was pushed forward and folded, before the sand was deposited, and the shore-lines were engraved.

The glacier was crossed in easterly direction along the northern border of the clear ice, inside the moraine covered part, which is similar to that along the northern border of Arkhangel Glacier. The surface of the ice rises but slowly, and at the point where the glacier enters the foreland it scarcely surmounts 150 m. The top of the ice wall there lies about 125 m. a. s. l., and as the ice wall is rather high, the bed of the above mentioned glacier river lies about 30—40 m. above the sea. A part of the wall is sliding down into the valley, and some times large blocks part from the glacier and tumble down upon the river bed. The zone of transition between the motionless stone ice and the ice in motion was clearly seen on the wall. In the stone ice thin layers of ice alternate with extremely thin layers of a dark and fine moraine-material. About 60—70 ice layers could be counted with a similar number of alternating layers of the dark moraine. The motion is as a matter of fact limited to the upper part of the ice. Where the ice is moving the layers are rather thick, but the thickness decreases rapidly towards the motionless part of the wall. If traced inwards the layers might possibly fade away into nearly homogenous stone ice. Though this glacier in two places has a calving front which shows some motion in two zones, the greater part of the front, however, is stone ice and has probably been motionless since the time of the 56 m. shore-line. So is probably the case also with the Arkhangel Glacier (Pl. XXI, fig. 2).

Stones were not seen on the surface of the ice, but here and there were heaps of a blackish gravel transported by the surface streams. These streams do not generally immerge till near the ice border and only in the places where the motion has caused crevasses to open on the surface. A single stream, however, immerged into a round hole in the compact ice close to the outer edge where no motion was probable and no crevasses were to be seen. (Pl. XVIII, fig. 1.)

A closer survey of the glacier above mentioned would undoubtedly have given interesting results, but I had only the time for a short visit. No time was left for search for shells in the moraine.

LYNGE who visited the peninsula to the west of the bay, found several of the levels known from the levelling at Arkhangel Bay. He found shore-lines 10 and 23 m. a. s. l., a fine flat at 30 m., an excellent flat at about 40 m., a great flat at about 50 m. and a corresponding shore-line somewhat higher. At 55 m. he found a piece of drift-wood 60 cm. of length and 10 cm. in diameter. At higher levels he observed shore-lines at about 95, 110, and 135 m. Below the 135 m. shore-line was a wide flat. Lines and flats were measured by aneroid. Photographs from the Pankratyeff Peninsula are shown in pl. XI, fig. 2 and pl. XXIV, fig. 2.

Summary.

It is evident from what has been stated above that the land also in this northern districts has been greatly submerged since the recession of the last ice sheet. A sinking to 239 m. is proved by finds of shells at the level, but much higher flats and corresponding lines have been observed, which are as sure strandmarks. These flats and lines have only been observed on the mainland on the southern side of Arkhangel Bay, and therefore it must be assumed that only in that part of the coast investigated, the ice front retired so much while the land was submerged to that level that the rocks were accessible to the wave action of the open sea. Berkh Island was at that time entirely submerged. Farther to the north the ice seems to have advanced into the sea with an unbroken front. On the northern side of Arkangel Glacier ledges have been observed on a knoll 210—320 m. a. s. l. These ledges have not been proved to be sure strandmarks, but if so they suggest that the ice sheet had been considerably reduced along the coast, before the rise of the land seriously set in. It may be a question whether the glacier ice melted entirely away on the foreland or partly kept its ground during the submergence. Shells have been found in moraine material on the ice 130 m. a. s. l. near the northern border of Arkhangel Glacier, but these shells may have been transported by the ice during a subsequent advance of the glacier. The upper shore-lines disappear below the glacier, and this fact proves that the lateral parts at least are younger than these shore-lines, but in spite of that, the central part of the glacier might be older than the shore-lines. It seems, however, somewhat improbable that a glacier should have had an existence for such a long time on an open coast, and submerged below the surface of the sea without a sufficiently thick and heavy moraine cover as protection against melting and floating. It must therefore be considered the most reasonable supposition that the glacier melted entirely away on the foreland. At the same time the inland ice must have been much reduced, for the land seems to have been rapidly rising during the first part of the uplift-period.

It is a striking fact that there is no zone of transition between the glacier and the ice free ground, covered by marine deposits. No trough or valley shaped depressions seem to have been excavated, an no unmistakable pushing up of the ground has taken place except in the case of the Pankratyeff Glacier, but there the pushing has only been observed near the present sea level. The present glaciers must therefore have entered the foreland as quite small ice tongues with only an inconsiderable erosive power and then little by little increased their dimensions both in length and width, and besides that, the ground may have been frozen to such a depth, that the glacier found no loose material to push forward. It is assumed that the upper part of the foreland had risen above the sea level, when this advance of the glaciers took place. The lower part of the foreland, on the contrary, cannot have been raised above sea level, for the Pankratyeff Glacier has pushed and folded the old moraine, which fact suggests that the moraine at the time of the advance was still submerged below the sea surface, and for that reason not frozen.

The increase of the ice sheet and the following advance of the glaciers, caused a sinking of the land presumably from about 20—30 m. to the 56 m. sbore-line. Since that time a slow decrease of the ice cover has been prevailing, and the land has by degrees risen to the present level.

II. A GENERAL REVIEW OF THE LANDFORMS.

Through the work of the various expeditions mentioned in the introductory part of this paper, the trend of the coasts of Novaya Zemlya have been fairly well made known. There are many rather detailed and sure charts of the west coast regions. With respect to the land surface, however, the maps are very primitive. The central inland is not studied, except along the routes of the parties who have traversed the country from coast to coast. Yet, as the land, on an average, is not more than 100 km. across, the inner parts are to some extent known by views from mountain tops near the coasts both to the west and to the east. I shall try to give here a general sketch of the landforms as far as they are known.

The land is situated between 70° 5′ and 77° north latitude and 51° 35′ and 69° east of Greenwich. As a northern continuation, or rather branch, of the Ural Range, Novaya Zemlya stretches in a curving arch to the northwest, north, and northeast for about 1 000 km., between Barentz Sea to the west and the Kara Sea to the east. Novaya Zemlya is the remnant of an ancient mountain range, folded up in Permian time, and, according to HOLTEDAHL a rather symmetrical range with a central zone of metamorphic rocks partly belonging to the uppermost Cambrian, but for a greater part, however, to the Devonian. The central zone is bordered, both to the west and to the east, by rocks of Carboniferous or Permo-Carboniferous age. The direction of the strike generally coincides with the longitudinal direction of the country. Matotchkin Strait forms a communication between Barentz Sea and Kara Sea, and divides Novaya Zemlya into two islands, the southern island making one third, and the northern island two thirds of the whole area, which is about 91 000 square km. (28, 29).

Along the west coast and probably in some places along the east coast runs a low and relatively flat foreland, a coastal plain similar to the Norwegian strandflat. The strandflat generally faces the sea with a vertical cliff, and it ascends slowly towards the mountains. The height of the inner border varies considerably, between 20 and 150 m. Most common it is about 100 m. The rock underground consists to a large degree of the weak Permo-Carboniferous rocks of the marginal belts, the beds with a steep, often nearly vertical dip. The rock floor is covered by a ground-moraine or till, varying more or less in thickness, which is often covered by a greyish-blue sand-mixed clay. The strandflat is generally grown over with an arctic and high-arctic vegetation of grasses, creeping bushes etc. In the northern parts the vegetation does not always form a continuous cover on the clayey soil.

The strandflat has been somewhat demolished by ice and wave action. The bedst conserved part is the Goose Land between 71° 40′ and 72° north latitude. It is a low undulating flat with a multitude of shallow lakes and tarns between low eminences and gently sloping ridges. „Cette plaine s'etoile de milliers de lacks qui scintillent au soleil comme une parure de petits mirroirs argents.“ (CHARLES-BÉNARD, 5.) Farther to the north the strandflat is interesected by bays and fjords, so far as to leave only some smaller or greater remnants round the extreme ends of the landarms or peninsulas between them. North of Nordenskiöld Bay the strandflat seems to be lacking, so that the sea directly washes the base of the mountains. North of Arkhangel Bay it appears once more, but there it is more uneven, with knolls and ridges, and the height is greater than farther to the south.

From the strandflat the land surface generally rises rather abruptly to the outer edge of a plateau-like ground, which is the most frequent landform between the fjords. The height of the outer parts of the plateaus has only been measured in a few places but seems to vary between relatively narrow limits, from 250 to 350 m. The plateaus rise gradually eastwards to about 500—600 m. East of Goose Land the mountain wall is cut by gorges through which the rivers enter the strandflat (5). Between the Goose Land and Cape Britwin the western edge of the plateau land is cut by broad and flat ice-worn valleys.

The land south of the Goose Land is rather low. On the eastern side of Kostin Shar there are mountains, no doubt, rising to about 800 feet according to HEUGLIN (20, p. 95) and PEARSON (56, p. 121), but CHARLES-BÉNARD found a passage running from this sound to the east across the country, where the divide does not exceed 70 m. The landscape was an undulating tundra with low knolls and flat valleys, lowering slowly to a table shore to the east (5). TCHERNY-

SHEFF found, southeast of Karmakuly, finely ice-worn valleys with even and monotonus slopes, running inwards from the coasts both from the west and the east into the plateau land, which does not rise above 500 m. a. s. l. The east coasts faces the Kara Sea with high cliffs rising to about 30 m., and therefore the rivers generally enter the sea through deep gorges (75, p. 139 and 69, p. 38). A strandflat has not been mentioned and must very likely be lacking.

The coast regions between 72° 30′ and 75° north latitude are characterised by a series of fjords and valleys. Both the strandflat and the marginal plateaus within this area are interesected by bays and fjords, and the transversely running valleys penetrate into the central zone of the range, sometimes forming continuous passages between the western and eastern coasts. The most important passage of this kind is Matotchkin Strait. This sound resembles in the main a Norwegian fjord, and it offers an excellent cross section through the whole country. To the west a greater part of the marginal zone is lacking between the entrance of the Strait and Sukhoi Noss, and is replaced by a large and open bay. The other fjords farther to the north at the west coast form broad basins to a great extent bordered by lowlands along the intervening peninsulas, but the inner parts of the fjords that enter into the metamorphic central range show a more typical fjord character, being long and narrow, and surrounded by steeply rising mountain slopes, with cirques, saddles and adjoining valleys. On the east coast, on the contrary, the fjords seem to be of a typical form, without a broad basin or an open funnel-shaped entrance.

Passages crossing the inner mountain region from one coast to another have been found between Krestovii Fjord and Rosmysloff Fjord, and between Mashigin Fjord and Zivolka Fjord. If the ice was taken away there might be a sound between Mashigin Fjord and Zivolka Fjord similar to Matotchkin Strait.

In Novaya Zemlya the transverse valleys are predominant. They must have been started and deeply cut down by river action long before Quaternary times. During the Ice Age they have been widened and deepened to the present form. Lengthwise valleys are met with in the vicinity of Matotchkin Strait, especially near the entrances both to the west and to the east. These valleys are at all events older than the last total glaciation, as they have been deeply eroded by the ice, often below the present surface of the sea. Such lengthwise valleys are: Matotchka Valley, a part of the Strait west of Cape Morschewoi, Belushii Bay with adjoining trough valley, and Gubina Bay to the east. In the middle part of the Strait some lengthwise valleys open on the sound, but they seem to have only an inconsiderable length, and their floors generally rise steeply inwards from the sea shore. Apart from Chalhonik and Baer Valleys, they have not been properly worked either by the river action, or by the ice, and may not be old. Also elsewhere several longitudinal valleys have been met with in many places, but the are only of secondary importance for the landform as a whole. Most of them are quite young gorges or canyons, which either have come into existence after the recession of the last ice sheet, or have only been inconsiderably worked upon by the ice.

The most elevated part of Novaya Zemlya is the inland area between the fjord regions by the coasts. It comprehends the central part of the southern island north of Bessimyannii Fjord and the northern island to 75° north latitude. Within this area the heights of the summits are quite considerable. According to HÖFER, who from the Wilczek Spitze had a splendid view of a greater part of this territory, a great number of summits and ridges were to be seen both to the south and southeast and to the north and northeast surmounting 11—12 hundred m. (31, p. 30). Matotchkin Strait is no division between mountains of different heights and types or between different landforms.

Most of the mountain tops are rounded and indubitably ice-worn, at all events to an elevation of 1100 m. Some of the loftiest summits are of a conical form surrounded by talus-slopes, but even the Wilczek Spitze with an elevation of 1186 m. had a small flat on top, and it is an obvious conclusion that this top also was originally ice-worn and rounded all over, and the same must be the case with the other tops of corresponding height in this loftiest part of the country. No indisputable nunataks from the time of the greatest ice-covering have up to the present time been pointed out in Novaya Zemlya, and it is doubtful if such mountains are to be found.

On the west coast north of 75° north latitude there are neither fjords nor valleys in the strict sense of the word, but here often appear islands and islets off the coast separated from the main island by sounds. The lowest ones are undoubtedly remnants of an once larger and more continuous strandflat, for instance the Krestovii Islands, but all the higher ones are separated parts of the marginal plateau. Some of the islands have later on been connected with the mainland again by shingle or sand bars, like, for instance, the Admiralty Peninsula and the Pankratyeff Peninsula. Instead of fjords wide and open bays prevail, which partly wash the base of steep mountain walls, and partly are surrounded by uneven lowlands, remnants of a demolished strandflat. The valleys are represented by the broad and steep-sided notches or saddles through which the glaciers from the inlands advance, either stopping on the low foreland or entering the sea with a calving front. On the east coast the coast line is for a long distance between Cape Edward and Cape Middendorf a continuous ice cliff, "an even and high inland ice, no mountain peaks visible", according to the map by STUXBERG, member of the Swedish expeditions 1875 and 1876, which had two stations close off this coast.

The heights of the mountains decrease towards the north, and between Arkhangel Bay and Pankratyeff Peninsula the medium height seldom seems to surpass 400 m. The northwestern coast between Cape Nassau and Cape Mauritius is for the greater part a continuous ice front. According to a map by SEDOV 1913, (Zapiski pogidograffii, vol. 42, 1918, Petrograd), some nunataks rise above the ice sheet to an elevation of about 1000 m. Along the east coast north of Cape Middendorf stretch relatively high mountains, which prevent the inland ice from advancing to the sea. The indication of the maps has been confirmed orally by the late captain STENERSEN who was acquainted with this part of the coast.

On the southern island the present ice cover is in fact confined to the mountain region along Matotchkin Strait, where several short valley-glaciers descend to about 180 m. a. s. l., draining ice fields between the neighbouring mountains. East of Karmakuly TCHERNYSHEFF found glacier ice at the bottom of two valleys called Obtsheidei to the west of the divide, and on the east side of the divide the Krotov River made its way between ice walls as far as its course was followed. These accumulations of ice lay between 400 and 500 m. a. s. l. (75, p. 138) and are most probably remnants of the last inland ice, at present reduced to motionless stone ice or "dead glaciers" near the snow-line.

North of Matotchkin Strait all depressions between the mountains are filled by ice that sends out glaciers in three directions, to the Strait and to the west and to the east. To the Strait descends the Tretyakoff Glacier, which advances nearly to the prensent sea level, and besides this glacier some smaller glaciers are seen, for instance the glacier that enters the bottom of the Chalhonik Valley 130 m. a. s. l. An attempt at determining the site of the snow-line by taking the arithmetic mean of the heights of the upper and lower border of a couple of local glaciers, gave as result 580—590 m., which agrees fairly well with the supposition that the ice accumulations observed by TCHERNYSHEFF lie near the snow-line.

On the southeastern slope of Mityoucheff Mountains several proper cirque glaciers descend generally to about 180 m. The largest glacier, however, descends to between 70—75 m. above the sea. On the northwestern side of the mountains a glacier has been seen advancing to near the sea shore. All the glaciers mentioned above are as a rule encircled at their lower end by two more or less well developed horse-shoe-shaped moraine ridges, the one in only a short distance from the other.

Farther to the north on the west coast glaciers descend to all fjords, but a calving front has not been met with till in Mashigin Fjord. Between Krestovii Fjord and Rosmysloff Fjord there is continous glacier ice, Gervais Glacier advancing to the west, and Makaroff Glacier advancing to the east, to the head of Rosmysloff Fjord. ROUSSANOFF, who passed along this glacier, found the ice divide at an elevation of 350 m. a. s. l. (5). In Mashigin Fjord two glaciers are calving, Lacroix

Glacier and Boule Glacier. The last-named glacier advancing to the west and Ibis Glacier to the east form together with University Glacier a continous ice connection between the west coast and the east coast. The ice divide lies about 350 m., and is somewhat nearer Mashigin Fjord than Zivolka Fjord. An attempt at determining the elevation of the snow-line here gave 450 m. (cp. map by HOLTEDAHL pl. XXIX).

At the head of the bay north of Cape Borisoff there are two glaciers of the same type as farther to the south, but from the Admiralty Peninsula northwards the glaciers are either piedmont glaciers, or, at all events, glaciers that cross the foreland, bordered by steep ice walls, and often forming ice cliffs in the sea. If their thickness should increase, they would most probably unite, and cover the foreland as a whole. The most northern part of the west coast is for the greater part an ice front, and so is a greater part of the east coast north of Zivolka Fjord.

According to what has been stated above, the present glaciation of the southern island is of the alpine type. The interior land between Matotchkin Strait and 75° north latitude, on the contrary, is covered by a continuous network of valley glaciers that make their way between the nunataks, and united to greater ice streams in the main valleys enter the heads of the fjords. In this part of the country the marginal plateaus are either completely free from glacier ice, or, if glaciers are to be found, they are only isolated cirque glaciers in localities, where the winter snow drifts together in exceptionally great masses, and is especially well protected against melting. North of 75° north latitude the whole inland area seems to be covered by a regular inland ice, so that only some parts of the rounded edge of a plateau land rise above the ice sheet. The parts of the foreland which are sheltered by these nunataks are free from ice. The contour map Pl. XXX shows in the main features the extension of the present ice cover of Novaya Zemlya.

The rivers on the outside of the glaciated territories are few and small, in 1921, at any rate, with only a slight flow of water, but the summer of this year, it is true, had an unusually dry weather. That the water body is considerable during the spring thaw is plain from the size of the river beds, which are out of proportions compared with the rivers that run in them. It must, however, be noted that in the spring time the soil is frozen close to the surface, so that no melting water enters the ground, and therefore the rivers must have a tendency to swell by thaws and to fall immediately when the thaws cease. As there are no bogs or marshes or other sorts of thawn soils to sop up and keep the water for any time, the rivers that have no afflux from glaciers or greater snow-fields may sometimes be dry rivers, apart from the afflux derived from the melting of the under-ground ice. This melting is, however, in ordinary years certainly inconsiderable.

The glacier streams are relatively small, and as far as the observations go, they get their most important supply of water from the ablation. On the surface of the glaciers there may on a varm summer's day run fairly large rivers, which either make their way to the ice-free lands by falling from the top of the glacier slopes, or disappear through sinkholes near the outer border of the glacier, to emerge again in some place or other on the slope of the ice above the base of the glacier. From the well or ice cave where the water emerges the river runs on a bed of ice, as a rule paved by cobbles and boulders. Such ice caves have never been observed at the base of the glacier fronts. Not even at the Laoroix Glacier, which enters a shallow fjord only 5 m. deep, has any sign of an emerging fresh-water body been observed. From these observations must be concluded that no important glacier stream is supplied by water from under the ice, and the melting at the bottom may not be considerable. Below the stone ice there may be frozen ground to some depth, and the ice is presumably frozen fast to the surface. Where the thickness of the glacier is great, the isothermal lines in the underground, however, may rise inwards from the border of the glacier in proportion to the increase of the thickness of the ice, and in some places the temperature at the bottom may rise to the melting point of the ice at that depth. If the thickness of the frozen earth on the ice-free land is supposed to be 100 m. or more, the thicknees of the glacier must be considerable, before the temperature at the bottom should be near zero and the underground not frozen. But if so, this circumstance ought to be of some importance for the erosive work of the glacier, the rise of glacier streams, and their ability to work.

The present shore-line is well developed. At all projecting headlands and along the outer parts of the fjords and bays the sea often washes the base of high cliffs, which at the eastern entrance of Matotchkin Strait even rise to 100 m. Excessive delta plains are generally found at the mouths of the greater glacier rivers rising, however, to only a few m. a. s. l., and in some places sand bars tie islands to the mainland, or separate lagoons from the sea. The shore-line is therefore relatively ripe, and as the sea cannot have staid for any great length of time near the present sea level, it must be assumed that the forming of a shore-line on an arctic coast must be going on rapidly, (cp. NANSEN and HOEL on Spitsbergen). The naked rocks seem to be more easily cut back by the sea than the frozen earth, for high bluffs of loose materials have not been observed. Rivers have cut deep gorges in the rocks, but deep cuttings in lose material are very seldom to be seen. To cut a bed through the frozen ground must therefore be a difficult work.

The ancient shore-lines play only an inconsiderable part in forming the land surface. Accumulated terraces and raised deltas are small and rare, and the ancient cliffs are not high enough to be compared with the recent ones. It must therefore be assumed that the raised shore-lines never were so well worked out or so deeply engraved as the recent shore-line, probably due to the short time left for their formation during the rise of the land.

The frozen ground is an excellent shelter against the forces that break down and alter the land surface. Only the summits and ridges, and cliffs too steep to allow loose material to rest upon them, are attacked by weathering; and by loss of the stones that fall from their sides and of the finer material blown down by the heavy winds they little by little are worn down, while the lower land keeps the surface-forms which it got thousands of years ago.

III. NOVAYA ZEMLYA IN GLACIAL AND POSTGLACIAL TIMES.

The inland ice that covered Novaya Zemlya during the Ice Age or Ice Ages had great dimensions compared with the present ice cover. This is proved by a great many observations mentioned in this paper. On The Lütke Mountains boulders transported from the central part of the island have been found to about 680 m. a. s. l., and on the summit of Syernaya Mountain similar boulders have been found at en elevation of 800 m., transported by the ice from the west. Mityoucheff Mountains, according to the measurements of Zivolka about 3200 Russian feet (974,3 m.) high (69, p. 59) have been distinctly rounded and worn by an ice sheet moving to the west across Serebryanka Fjord. The projecting peninsula north of Mityouschicka Bay is ice-worn all over, and boulders have been found. On the peninsula north of Mashigin Fjord a block of a Devonian coral has been found together with masses of other erratic blocks from the inlands. A similar find has been made on the outermost of the Krestovii Islands. Though this island lies in a considerable distance off the coast of the main island, it has, however, been overrun by the ice, which has transported a multitude of erratic blocks from the interior highlands. Besides that, all the mountains along the coasts have been rounded, and so is the case with the edge of the marginal plateaus too everywhere, except the upper part of the walls that in some places border the present glaciers. Rounded high mountains can be seen far inland from the outer coast line. Shaped in this manner are all mountains round the inner part of Mashigin Fjord with an elevation between 700 and 1000 m., and the nunatak that rises above Boule Glacier to the northeast, 800 m. high, is a rounded top. Along Matotchkin Strait most of the mountains have been rounded by the ice, but there are some summits of a conical form which may be primary nunataks. It must, however, be noted that the weathering under the prevailing climatic conditions preys on the tops with such an intensity that a rounded mountain top, which for a long time past was raised above the ice, may have lost its rounded form after that time. Wilczek Spitze has a flattened top, and that should not be the case if it were a primary nunatak consisting of hard and steeply inclined rock layers. WILCZEK and HÖFER built a pyramide of quartzite blocks on the top, and therefore the top must consist of this rock (31, p. 301).

Even if the possibility must be admitted that a few summits in the highest part of the mountain range in the vincinity of Matotchkin Strait are primary nunataks, the elevation of the mountain tops which as a matter of certainty have been rounded by ice action, is so great that the ice sheet that once worked on these mountains must have had a thickness of at least 1100—1200 m., above the present sea level. This vast ice cover stretched of course far beyond the highlands, and it is supposed to have formed an extensive and continuous foreland ice off the coasts similar to the ice barrier round the antarctic continent. The thickness of that ice barrier may have been at least 700—1000 m. close off shore, for Novaya Zemlya formed then the central part of a depression too large to be only due to an ice load resting on the land surface. Snow must have accumulated all over the ice sheet as long a the precipitation was great enough, for the surface of the ice surely rose above the snow-line of that time. The ice masses which from the highland region supplied the barrier ice presumably passed the border of the land existing at that time as a continuous ice flow, only to a small extent following the existing valleys and fjords, as the motion there may have been partly checked by the less movable ice barrier off the mouths of the fjords. The outer border of the ice barrier may have been a more or less continuous ice cliff similar to that of the antarctic ice barrier.

How many times Novaya Zemlya has been glaciated cannot be decided, but it must be assumed that the different ice ages and interglacial epochs of Northern Europe had their play also here. It is an obvius conclusion that during the Great Ice Age the ice masses from Northern Europe, Bear Island and Spitsbergen, advanced so far into the sea that an open and ice-free part of the Barentz Sea hardly existed, or if so, was so reduced that it would essentially influence the climatic conditions. If the Barentz Sea was filled by glacier ice, or, at all events, was constantly frozen, the precipitation might be too small to cause a heavy glaciation as far east into that ice desert as in Novaya Zemlya. It is therefore probable that during the Great Ice Age in Europe Novaya Zemlya was only sparingly glaciated, as was the case in Sibiria. It may be that, as the glaciation of Europe successively decreased, the intensity of the glaciation of Novaya Zemlya was increasing, so that the last glaciation in the latter region therefore is the greater one (cp. HESS 19, p. 377).

In whatever manner the earlier ice ages elapsed, however, the odds are that the great glaciation which is traced in Novaya Zemlya corresponds to the last glaciation of Northern Europe, the Mecklenburgian, according to GEIKIE (12).

It is likely that the glaciation of the Taimur Peninsula, mentioned by NANSEN and SVERDRUP (47 and 73), is of the same age. To that time Spitsbergen and Frantz Joseph Land must no doubt have been strongly glaciated.

How much Novaya Zemlya was depressed during the last glaciation cannot be settled, for no part of the land was accessible to the attack of the waves while the glaciation was at its greatest. The uppermost lines and flats, which can be presumed to be marine, lie between Bessimyanni Fjord and Gribovii Fjord 370 m. a. s. l., on the western slope of Mount Nansen 340 m. (doubtful), and at Arkhangel Bay 305 m. a. s. l. The uppermost indisputable marine shore-line, proved by finds of fossils or corresponding rock ledges, lies both at Gribovii Fjord and Arkhangel Bay 240 m. a. s. l. An essential part of the ice sheet had undoubtedly melted away before the uppermost strand marks on the west coast were formed, and it is likely that the peripheric part of the depressed area had somewhat risen, but the uplift may not as a matter of necessity have reached the central parts. It is thus possible that the land along the central range had not been much more depressed than the said uppermost strand marks show. They are to be found at a higher level to the south than to the north, either because the depression was greater, or because the ice barriere was earlier broken along the southern part of the coast than farther to the north. The fact that the uppermost indisputable shore-line has the same elevation in all places where it has been pointed out seems, however, to suggest that the depression had been much the same along the whole country, at all events north of Karmakuly.

A depression of 370 m. is supposed to be a minimum, and it is highly probable that the maximum depression was near 400 m. It was of about the same size as the depression of Spitsbergen and Northeast-Greenland. In 1920 WERENSKIOLD and HOEL measured a ledge with cobbles on Mount Dummer Kerl near the South Cape, and found 340 m., the highest strand mark known from Spitsbergen (78), and the coast of Northeast-Greenland at 77° north latitude has been depressed to abouth 400 m. according to KOCH (39, p. 441). On King Charles Land NATHORST found cobbles to 277 m. a. s. l., and on Frantz Joseph

Land KOETTLITZ found small rounded stones 237 and 333 m. above the sea (51, pp. 375—376).

The strand marks observed on King Charles Land and Frantz Joseph Land, must be presumed to be somewhat younger than the uppermost strand marks on the west coast of Novaya Zemlya, and the southern part of Spitsbergen, for the ice barrier must have been broken there on a later date than farther to the southeast and southwest.

There is reason to believe that the ice flow, which once passed the marginal plateaus of Novaya Zemlya with a broad and continuous front, had come to an end, before the ice barrier was broken. A further supply after that time only took place through valleys and fjords, and through the local ice streams that here and there passed the marginal edge in cutting saddles and flat valleys on their way. The motion of the fjord glaciers, however, would be brought to a stop against the motionless barrier ice off the mouths of the fjords, and the glaciers were in that way reduced to a kind of large cirque glaciers, which worked in a manner like tributary valley glaciers, stopped in their motion by a nearly dead glacier in the main valley. The Mashigin Glacier that once excavated the Outer Basin was probably one of that type. The bottom of the basin lies much deeper than the bottom at the entrance, and the basin is broad an flat with slowly ascending slopes, and all the rivers run through postglacial gorges. Valleys that may have existed before the last ice age have been rubbed out. The inner part of the land-arms between Mashigin Fjord an the northern Sulmenyeva Fjord, and between Gribovii Fjord and Bessimyannii Fjord, may have been worn down by glaciers of that type before the ice barrier was finally broken. When the 220 m. line was engraved the Mashigin Glacier had for the greater part melted away, since this shore-line can be traced to the Blaafjell Glacier on the southern side of Blaafjell Basin.

The other fjords between Sukhoi Noss and the Admiralty Peninsula were in all probability free from ice at that time. North of the Admiralty Peninsula the ice that covered the present foreland had undoubtedly melted away, so that the sea washed the naked mountain slopes. The supply of ice from the interior highland must have been brought to a stop, or was highly reduced.

The further progress of the melting of the ice can best be followed along Matotchkin Strait. In the wide bay between Cape Stolbovoi and Sukhoi Noss the ice front must have staid for a long time. Not till the land had risen to the 215 m. level had the sea access to the northern end of Mount Matotchka, where a rock ledge shows the site of the left flank of the ice cliff. The great ice masses here must have been due to the situation of the bay at the mouths of the great affluxes Matotchkin Strait and Serebryanka Fjord, situated in the loftiest mountain region of Novaya Zemlya.

On the east coast no traces of the 215 m. level have been observed, and therefore it must be concluded that there the ice as a continous ice sheet still entered the sea off the coast.

When the land lay at the 200 m. level, a distinct shore-line was engraved on the western slope of Lütke Mountains, and on the northern side of Mityouschikha Bay east of Sukhoi Noss. The ice front had accordingly been divided. The southern part, 10 km. broad, crossed the mouth of the Strait between Mount Matotchka and Lütke Mts. A northern part, at least of the same width lying between Lütke Mts. and Mityoucheff Mts., crossed the Serebryanka Fjord. It is possible that a third part staid for some time west of Mityoucheff Mts., but there was no opportunity to settle this question.

On the east coast the ice cover had by this time been so far reduced that the eastern entrance to the Strait was open. Then the best and most distinct shore-line that is known was engraved in solid rock 204,8 m. a. s. l. While this shore-line was engraved, the ice front crossed the Strait at Cape Poperetchnoi (Quer Cape), about 15 km. within the Strait. The ice was supplied both from the west through the Strait, and from the north through Belushii Bay, and judging from the strongly engraved shore-line, the ice front must have staid for a relatively long time in the said place, probably on account of a favourable situation with regard to supply of ice, the like not to be found in any place on the west coast.

Northeast of Serebryanka Fjord on the eastern slope of Serebryanka Valley two very distinct shore-lines have been observed, the upper line about 180 m. a. s. l. This line, which has been measured by horizontal aim with the levelling instrument, does not pretend to be measured exactly, but is safe enough to show that the Serebryanka Valley was free from ice when the 175 m. line was engraved, a shore-line pointed out in many places along the west coast, but not traced along the Strait. The Strait, however, from the entrance inwards seems to have been still filled, or at all events partly filled by ice, probably because the glacier there was protected against the attack of the sea by Lütke Mountains and Loshkin Mountains, and was supplied through Tchirakina Valley and Choumilika Valley, and from the east through the Strait. That the valleys just mentioned were filled by ice during that stage cannot be doubted, since the smaller Matotchka Valley at that time and later on was filled by ice south of the moraine ridges, as described in detail on pp. 17—20.

During the following time the ice was broken in the western part of the Strait to beyond the mouth of Choumilika Valley, and to the east the Strait glacier retired past Belushii Bay and Gubina Bay westwards to the narrow part of the Strait west of Baer Valley, where it stopped for a time. This recession was followed by a rise of the land to a shore-line which at Tyouleni Bay, (anchorage 11), has an elevation of 146 m., and in Matotchka Valley 160 m. a. s. l. The rise of the land had accordingly been greater to the east than to the west. It is possible that relatively greater masses of ice had melted away in the eastern part of the land than to the west, and that the uneven rise of the land was due to this circumstance.

There can be no doubt that at the time when this shore-line was engraved large glaciers still entered the Strait. In Matochka Valley a glacier had its front along the moraine ridges there. In Baer Valley a large glacier advanced into the Strait with a fan-shaped lobe that nearly barred the Sound, and in Tchirakina and Choumilika Valleys undoubtedly great glaciers still existed.

The shore-line above mentioned has been pointed out in all localities where levelling has been undertaken. On that account the shore-line cannot be explained without presuming a climatic oscillation not likely to be of local importance. That the glaciers have been advancing, at all events on the west coast, can scarcely be doubted, but whether any noteworthy immersion took place is difficult to settle. In Matotchkin Strait the Sound glacier had an extent as map pl. XXVII indicates or thereabouts. In length it fell somewhat short of the glacier that nowadays fills the passage between Krestovii Fjord and Rosmysloff Fjord.

During the next melting period this ancient ice-filling melted away, and the land rose to the 121 m. line. This shore-line has been pointed out everywhere on the west coast, and is the first shore-line that can be traced all along the Strait. Large glaciers still entered the Strait, for instance a great Tretyakoff Glacier, a Baer Glacier, and a glacier in the Chalhonik Valley. This glacier deposited the moraine that crosses the valley at the upper end of the delta with an elevation of 115—120 m. In the Chalhonik Valley can be seen that the further recession of the ice did not go on continuously, but at intervals as before. Three consecutive moraine steps show not only pauses in the recession, but allow an approximate determination of the size of the glacier at the different stages. Whether more moraine steps are to be found in this valley cannot be said, as the upper parts have not been explored. To the three moraine steps probably the three shore-lines in the diagram marked IX, VIII, and VII may correspond.

It can scarcely be doubted that the ice cover during this melting period at last retired beyond the limits of the present glaciation. The Chalhonik Valley became free from ice, and no glacier has since then advanced down the main valley. The glaciers round the inner part of Mashigin Fjord were reduced to "dead" glaciers or disappeared, but some glaciers only retired beyond their present limits.

The foreland between Arkhangel Bay and the Pankratyeff Peninsula must have been free from ice during the time when the land was submerged below 100 m., for this part of the coast was fully open to the force of the seas, and the supplies of ice were no doubt much reduced also there, if not entirely brought to a stop.

When the land had risen to a level probably only a few m. above the present sea level a change in the climatic conditions seems to have taken place. The recession of the ice not only ceased, but what was more than that, a general increase of the ice cover set in. It is not probable that the ancient ice sheet had totally disappeared, and therefore there cannot be talked of a new glaciation. Owing to this increase of the ice the retired glaciers once more advanced, and new glaciers came into existence, and crept down the old glacier beds. To the north glaciers entered the foreland. Arkhangel Glacier crossed the upper shorelines, the 62 m. line included, and the Pankratyeff Glacier pushed and folded the ancient moraine at its front. As no moraine or marine deposits seem to have been folded up at higher levels, it must be presumed that the glaciers advanced over a frozen ground, the more so as these glaciers did not excavate any beds of their own, but seem to rest on an unaltered land surface. The pushing and folding must therefore have taken place below the surface of the sea. West of the delta heading Straumsnes Bay in Mashigin Fjord a glacier overran the 71 m. line, and covered the beach with a moraine of blocks and boulders. Round the inner part of Mashigin Fjord glaciers stepped out upon the old dead glaciers, often without advancing beyond their limits. In the Chalhonik Valley a glacier advanced down the western slope partly overlapping the ancient terminal moraines on the valley floor, and on the southern side of the Strait a glacier invaded a land surface overgrown with vegetation etc.

It has been quite imposible to fix the accurate site of the shoreline when this advance of the glaciers took place, but some observations suggest a sea level of between 10 and 20 m. The pushed and folded moraine in front of Pankratyeff Glacier is situated between 5 and 8 m. a. s. l. On the north side of Bessimyannii Fjord a river has left its postglacial canyon near the present outlet. The part of the gorge such left has been filled by marine sediments to about 40 m. a. s. l. The botten of the gorge is estimated to lie between 10 and 20 m. above the present shore-line. On the north side of the Outer Basin a river has left its bed in a similar way, and at the head of some small bays old cliffs seem to disappear below the marine sediments deposited between ancient ridges from the bay heads inwards.

Of essential importance is a find of peat made by the Russian expedition to Novaya Zemlya in 1921. According to some proof-sheets of a paper in Russian dealing with the preliminary results of the expedition, sent to O. Holtedahl by the leader af the expedition Dr. P. Wittenburg, the expedition found the following profile measured and described by K. Maljarevskij:

1. Cover of vegetation,	
2. Humus-horizon	15—16 cm.
3. Dark-grey layer of humus	7— 8 „
4. Dark clay	26—27 „
5. Layer of peat	2— 3 „
6. Dark-brown clay with specks of an ochreous yellow colour	21—22 „
7. Dark-grey clay with vegetable remains	19—20 „
8. Frozen earth with numerous vegetable remains	55—60 „
9. Fossil ice	100— ? „

A preliminary examination of the peat has been made by V. Dokturowskij, who has round that the peat seems to be of the „hypnum-cyperaceae“ type mixed with *Sphagnum squarrosum* and very small remains of grasses. The locality was a river valley at Olginskoe (Krestovii Fjord). In the translation at hand the height of the profile above the sea was not given.

In another place at the river Krestovaja, 31 m. a. s. l., at the base of a glacier descending from the mountain, the Russian expedition found the following profile:

1. Cover of vegetation,	
2. Humus-horizon	11—12 cm.
3. Grey clay	31—32 „
4. Dark-grey clay with vegetable remains	6— 7 „
5. Peat	6— 7 „

The peat rests upon frozen earth above fossil ice. An analysis of this peat shows that it is of the ”hypnum-cyperaceae” type. The remains of hypnum have been well conserved. Pollen of any species of trees have not been found.

As peat is not formed on the north Island of Novaya Zemlya in the present time, the authors of the paper conclude that the fossil peat has been formed during the more favourable climatic period after the Ice Age in which the peat found by Sukatscheff in the Karsk tundra has been formed, (Messager Météorologique vol. XXXII 1922 No. 1—4, pp. 25—43). Professor V. S. Dokturovskij in Moscow and M. M. Jurjew in Petrograd are working out a detailed report on the material of fossil peat found in Novaya Zemlya.

The first profile has two horizons with vegetable remains, the layer 5 between two layers of clay and the layers 7 and 8 between clay and fossil ice. The second profile has only one horizon with vegetable remains between ice and clay. The profiles show that some parts of the postglacial time have been favoured with a better climate than now, since the forming of peat was possible. These climatic improvements cannot, however, have been great, or lasted for any length of time, for the peat layers are very thin, and the vegetable remains found belong to species even now common in the arctic region. *Sphagnum squarrosum* was found by LYNGE to Mashigin Fjord, and Mr. LID of the Kristiania University, who has worked out the material collected of *sphagnaceae*, writes in his manuscript that "*Sph. squarrosum* seems to be the most wide-spread *Sphagnum* in Novaya Zemlya." According to LID this species is also the most common *Sphagnum* in Spitsbergen, where it has been found in many places. Another species of *Sphagnum*, *Sph. fimbriatum*, Wils., *var. concinnum*, Berggr. was found by LYNGE on the Admiralty Peninsula.

If the clay layers should be found to be of marine origin, or be deposited in a place where the situation of the shore-line would have influenced the deposition of the clay, these layers should prove that two oscillations of the shore-line had taken place in postglacial time, but as the height of the profile is not at hand no safe conclusion can be made. With reference to the facts given above it must, however, be reasonable to think that the lower horizon with vegetable remains was formed when the shore-line was situated near its lowest stand before the above mentioned advance of the glaciers. This question will once more be dealt with in a following chapter.

After the advance of the glaciers the land sank to a shore-line marked VI in the diagrams (Pl. XXVII and XXVIII) 54,4 m. a. s. l. This shore-line is one of the best engraved shore-lines in Novaya Zemlya, and has been pointed out in all places where levellings have been undertaken, and has been seen nearly everywhere else. This level is remarkably well developed with flats, cliffs and bluffs which is no general feature with the other shore-lines. If the supposition of the stand of the shore-line at the time of the advance should be fairly right, this sinking of the land was about 40 m.

While the land lay submerged to this level the first drift-wood seems to have been washed ashore in Novaya Zemlya. Drift-wood was found by captain MELSOM at Lake Lomvand east of Tyouleni Bay about 200 feet a. s. l. (cp. the journal of the Rosenthal expedition, 20, pp. 253—254), and LYNGE found a piece of drift-wood on the Pankratyeff Peninsula 55 m. a. s. l. Whether this drift-wood had come from Sibiria or from Russia, or from any place farther to the southwest, cannot be settled, and is also of secondary importance. The occurrence of drift-wood shows at all events that the basins of the rivers which entered the northern seas vere forested at that time.

Since the time of the 54,4 m. line the glaciers have been slowly retiring especially in the southern part of the land. Most of the glaciers along Matotchkin Strait have retired from the terminal moraines that mark the outer limit of the advance. Behind these moraines is another moraine step from a later advance which the glaciers now are leaving, or already have left. A local glacier on the south side of Arkhangel Bay has retired, leaving distinct lateral moraines along its former bed, and the surface of Økland Glacier on the south side of the Middle Basin lies about 10—13 m. below the lateral ridges that mark this last advance.

The peripheric parts of the now existing glaciers, both front and flanks, have often passed into stone ice, and to the north the moraine cover has in many places been so strongly washed by the sea that distinct shore-lines have been engraved.

Five shore-lines younger than the 54,4 m. line have been measured, about 42,6, 31,8, 22,2, 12,7 and 3,1 m. as means of the measurements. It is probable that one of these shore-lines corresponds to the second moraine step above mentioned, most likely the 31,8 m. line, and that a new sinking of the land has taken place, but it cannot be proved. If so the upper peat-layer in the first profile described in the paper cited above may have been covered with clayey deposits at that time. No drift-wood has been found between 50 and 23 m. Many places on the west coast have been surveyed in order to get a general idea of the distribution of things washed ashore, but nothing was found between the said levels. In the 22 m. level, drift-wood appears once more, and it is of a special interest that axe-marked logs have been found at this level. If these finds are from primary places, as I think they are (see p. 72), they prove that he shore-line in question must be relatively young and not older than the Iron Age.

The next shore-line is situated about 10 m. a. s. l. along the coast line, and at about 15 m. around the Blaafjell Basin. Here it is very distinct, and looks so newly made as if it recently had been left by the sea (Pl. XII, fig. 1). The land surface below the shore-line is of a different colour than the land above, as it is more sparcely grown over with vegetation. Along the outer coast it is not always sharp, and along Matotchkin Strait it is not easily pointed out. Masses of drift-wood have been observed in several places on the west coast, for instance on the western side of Berkh Island where large trunks, often axe-marked, have been found. On the terminal moraine of the Pankratyeff Glacier a piece of wood with an iron nail has been found close above this level, 12 m. a. s. l. Some facts seem to show that the rise of the land from this shore-line has taken place since sailing in these waters became common. Pankratyeff Peninsula, formerly an island, has been connected with the mainland during the last centuries by a shingle bar. From Arkhangel Bay ran some centuries ago a sound, deep enough for small vessels, to the north between Litchutin Island and the mainland (69, p. 56 after KRESTININ II, 2), but at the present time not even a rowing boat can pass through. In 1596 BARENTZ found an Admiralty Island. When LÜTKE visited this part of the coast about 220 years later, the island was not yet connected to the mainland, but the sound vas so shallow and filled up with shoals that it was not passable (46, p. 298). In our days the former island is closely tied to the main island by a narrow strip of lowland. The lagoon at the mouth of Matotchka River was formerly a good anchorage etc. The 12,7 m. shore-line must therefore be quite young, from the Middle Age or younger (cp. 8, pp. 307—308). During the rise from this shore-line Boule Glacier has retired 200 m.

Recent things such as wreckage, sawn timber, glass floats and the like have been washed ashore in several places on the west coast, and are generally found to about 3—4 m. a. s. l. and to 5 m. in places open to the force of the waves. Things found at an elevation of 7 m. or more, have never a modern aspect, and must therefore have been washed ashore before the rise of the last three metres. This rise is believed to have taken place during the last 150 yars, a greater part even between 1770 and 1820. ROSMYSLOFF, who sounded in the western part of Matotchkin Strait 1769, found depths between 9 and 15 saschéns, (1 sashén = 2,13358 m.) (46, p. 73), but on the maps of to day the depths lie between 6 and 12 saschéns. ROSMYSLOFF found some of the river mouths so deep that they vere open for boats and small unloaded fishing vessels (46, p. 307), but when LÜTKE visited the Strait 1822 no such depths were to be found. When PACHTUSSOFF wintered at Tchirakina River 1834—1835, the mouth of that river seems to have been open for vessels, but the Rosenthal expedition could not enter the delta in a rowing boat (20, pp. 53—54). The land must therefore have been rising since the time of PACHTUSSOFF, buth the rise cannot have been great, for according to LÜTKE the depths at Pomorskaya Bay seem not to have altered much since his time (46, p. 243). His descriptions on this subject are indeed somewhat vague. On the east coast this last rise of the land must have been quite inconsiderable, for no sure shore-line has been pointed out there, and the ruins of the log house of ROSMYSLOFF lie still close to the sea shore (56, p. 130 and fig. 57).

At the present time the rise of the land seems either to have come to a standstill or is going on with an extremely slow rate of motion, for the recent shore-line is better developed than any of the shorelines from former days, except the 205 m. line along the eastern part of Matotchkin Strait.

IV. AN ATTEMPT AT CORRELATING THE SHORE-LINES OF NORTHERN NORWAY, NOVAYA ZEMLYA AND SPITSBERGEN.

It has been maintained in this paper that a vast ice sheet once covered Novaya Zemlya and the surrounding sea bottom. How far off-shore the border of the ice sheet went, is not known. If an average distance of 150 to 200 km. be assumed the eastern border would reach the middle part of the Kara Sea, and the southern border would touch the European mainland. Near the central part of the ice sheet the land was probably depressed to about 400 m. below the sea level, and it must be supposed that the outer limit of the depression reached at least as far off the coasts as the outer border of the ice sheet. This depression is supposed to have been due to the pressure of the ice masses, and was thus a local phenomenon. At the entrance of the White Sea the land surface seems to have been somewhat elevated above the sea level at that time, according to RAMSEY (33, p. 137), and the Kanin Peninsula has scarcely been submerged (60), but east of this peninsula a submergence increasing eastwards must have taken place, for KEYSERLING (31, p. 302), found shells in the main valley of the Petsora Basin between 68,5° and 65,5° north latitude, once an estuary of the Barentz Sea. The coast from the Petsora Basin eastwards beyond Yugor Strait has also been depressed, but no report on measurements or other informations of the extent and depth of the depression have been at hand. PEARSON found drift-wood, among others logs 35—40 feet long and over one foot in diameter, to about 300 yards from the sea shore there, and he remarks that "that at the top must have been 35 feet above present sea level, telling of a considerable elevation of the land since it floated in from the sea", and "none of it had been there less than three hundred years, and some probably much longer" (56, p. 111). The length and diameter of the logs are dimensions commonly seen in the 12,7 m. level, but not in higher levels where drift-wood has been found. The hills that he describes on p. 112, consisting chiefly of sand "without any sign of stratification, containing erratics" must be moraines.

The northern part of the Ural Range has once been much glaciated (52 and 21). This glaciation must have been simultaneous with the glaciation of Novaya Zemlya, and along the line of a possible contact between these ice sheets the deposition of the moraines just mentioned may have taken place. At the same time the glaciated part of the Ural Range and the neighbouring lowlands must have been depressed, but as the depressions probably joined at Yugor Strait or near there, the submergence of the coasts along the Strait was scarcely great compared to that of Novaya Zemlya. The depresion of the Petsora Basin may not have exceeded 150 m. (cp. 33).

Yamal (Yalmal) Peninsula seems to have been somewhat depressed at that time (68), but the depression must have been quite inconsiderable, for no find of shells or drift-wood has been reported (cp. 53, p. 198). Nor was a noteworthy submergence of this peninsula probable, at all events of the northern parts, as it was situated in the presumed peripheric area of uplift. According to Sverdrup (73) the Taimur Peninsula has been depressed after the recession of the last ice sheet there, a depression that seems to have reached the basin of Yenisey too (53), and it is likely that this depression was contemporaneous with those of the northern part of the Ural Range and Novaya Zemlya, but it must have been an independent one.

It is probable that the depression af Novaya Zemlya to the north and northwest communicated with a great depression comprehending the area round and between Frantz Joseph Land and Spitsbergen, (and possibly Greenland and the northeastern part of the North American Continent). These depressions to the east and north, and a depression of Fennoscandia to the south, seem to have been so extensive, that a greater part of the bottom of the Barentz Sea may have been situated below its present level. Bear Island must at all events be presumed to have been submerged at that time, for in 1922 Hoel and Werenskiold found rounded stones there to 42 m. a. s. l. As no elevated shore-lines have been observed, it is likely that this island had early risen to the present level.

After the melting of the off-shore part of the ice sheet of Novaya Zemlya, the land lay still about 240—200 m. lower than now. A greater part of the southern island was then submerged below the sea surface, and even if the depth of the depression is assumed to have strongly decreased to the south, Waigats must have been submerged at that time. There was accordingly a passage 250—300 km. wide bethween the Barentz Sea and the Kara Sea.

There is reason to believe that the further melting of the ice that still filled fjords, sounds and valleys especially in the northern parts of Novaya Zemlya, now as before was mostly due to the action of the sea water. In Northern Norway dry river beds very often are to be found along sides of valleys that once have been filled by ice, showing that great rivers from the inland ice fields ran to the sea along the sides of the glaciers, and such glacier rivers had often come into existence 500 m. or more above the contemporaneous sea level, but in Novaya Zemlya no such river beds have been observed, and therefore it must be inferred that they never were of especially great importance, in short, the melting on the surface of the inland ice may not have been much greater than it is nowadays. The ice melted away with the same rate along the east coast as on the west, and therefore a strong branch of the Gulf Stream Drift must have entered the Kara Sea. The temperature of the surface water might have been somewhat higher than now, but even if this was the case on the high seas, the melting of great masses of ice along the coasts would lower the temperature to zero, and after the recession of the ice to the inland regions the time of high temperature may have passed away, giving place to a temperature not much different from what it is now, for from the list of fossil mollusks found in Novaya Zemlya it will be seen that, while the land was depressed below the 12,7 m. level, not a single boreal mollusk species reached its coasts, and no littoral mollusks have ever lived there. The conditions of life for a littoral mollusk fauna must therefore have been unfavourable. Not even *Mytilus edulis* whose demands are quite modest, as it is to be found along a coast so blocked up by ice as the east coast of Greenland to 66° 30′ north latitude (36, p. 300 and 50, p. 304), was able to advance so far to the northeast. In the summer of 1921 all the members of our expedition were on the look-out for this mollusk so easily identified, but not a single specimen has been found above 10 m. a. s. l., that is far below a level corresponding to that to which this species has been found in Spitsbergen and King Charles Land. The specimens found seem for the greater part to originate from the present shore or near to it. They were never embedded in sand or gravel, and are quite recent-looking. *Mytilus edilus* cannot therefore have immigrated till the time of the 12,7 m. line. As fossil it has been found to the Pankratyeff Peninsula 1921, and living to Waigats by the Swedish expeditions (72, p. 151). To about the same elevation and the same latitude *Buccinum undatum*, Lin, has been found in a fossil state, if the determination be correct.

Whether *Mytilus edulis* has been found living farther to the north than Waigats, I do not know, as I have had no opportunity to see the Russian reports on these subjects, but if so, this species may be regarded as a relict from a more favourable time.

List of fossils.

1. *Pecten islandicus*, Müll.: N. Goose Cape 6—7 m., Matotchka Valley 65—70 and 120 m., Serebryanka Bay 10 m., Belushii Bay 110—115 and 130—142 m., Krestovii Fjord near sea level, Mashigin Fjord 90 m., Arkhangel Bay 110—118 m., Zivolka Fjord 30 m., the northern Krestovii Island near sea level.
2. *Mytilus edulis*, Lin.: N. Goose Cape 6—7 m., Serebryanka Bay about 10 m., Krestovii Fjord near sea level, Mashigin Fjord near sea level, Admiralty Peninsula 8 m., Pankratyeff Peninsula near sea level.

3. *Leda minuta*, Müll.: Matotchka Valley 65—70 and 120 m.
4. *Cardium grønlandicum*, Chemn.: Matotchka Valley 65—70 and 120 m., Belushii Bay 50—52 m., Mashigin Fjord 90 m., Litchutin Island 100 m., N. Goose Cape 6—7 m.
5. *Astarte borealis*, Chemn. & var.: N. Goose Cape 6—7 m., Bessimyannii Fjord 5—30 m., Matotchka Valley 65—70 m., and 120 m., Belushii Bay 50—52, 105, 130—142 m., Krestovii Fjord 0—25 m., Mashigin Fjord 0, 30—50, 90, 100, 120 and 163 m., the last find on a glacier; Zivolka Fjord 15 m. on the glacier, Admiralty Peninsula 115 m., north of Arkhangel Gl. 63 m. and on the moraine of this gl. 130 m. above ice.
6. *Astarte eliptica*, Brown.: Matotchka Bay 65—70, 120 and 140—170 m., Belushii Bay 50—52, 80—90, 105 and 130—142 m., Sukhoi Noss 70—111 m., Berkh Island 50 m.
7. *Astarte montagui*, Dellwin & var.: Matotchka Valley 65—70, 120 and 140—170 m., the Middle part of the Strait 10 and 85 m., Belushii Bay 105 and 130—142 m., Sukhoi Noss 70—111 m., Mashigin Fjord 30 m.
8. *Astarte crenata*, Gray & var.: Belushii Bay 50—52, and 100—115 m., Krestovii Fjord 25 m., Mashigin Fjord 30—50 m., and Admiralty Peninsula 115 m.
9. *Macoma calcaria*, Chemn.: Matotchka Valley 65—70 m., Belushii Bay 100—115 m., and Mashigin Fjord 30—50 and 90 m.
10. *Mya truncata*, Lin. & var.: N. Goose Cape 6—7 m., Bessimyannii Fjord 5—30 m. Gribovii Fjord 150—160 m. and 200 m.? Matotchka Valley 65—70, 120 and 140—170 m., the Middle part of Matotchkin Strait 85 m., Belushii Bay 50—52, 80—90, 90—100, 105, 115 and 130—142 m., Serebryanka Fjord 150 m., Sukhoi Noss 70—111 m., Krestovii Fjord 25 m., Mashigin Fjord 30—50, 40—45 and 90 m. on a moraine above ice, 100, 120 and 163 m. on a glacier. Zivolka Fjord 15 m. on a glacier and 30 m. Near Cape Borisoff 80—95 m., Admiralty Peninsula 115 m., Arkhangel Bay 110—118, 120, 140—150 m., north of Arkhangel Gl. 63 m., Litchutin Island 60 and 100 m. and the northern Krestovii Island near the sea level.
11. *Saxicava arctica*, Lin. & *pholadis*, Lin.: N. Goose Cape 6—7 m., Bessimyannii Fjord 5—30 m., Gribovii Fjord 150—160 and 200 m., Matotchka Valley 65—70, 120, 140—170 m., Belushii Bay 50—52, 70, 80—115, 130—142 m. Queer Cape (anchorage 13) 70—82 m., Serebryanka Fjord 20 and 150 m., Sukhoi Noss 70—111 m., Krestovii Fjord 25 m., Mashigin Fjord 30—50, 40—50 and 90 m., on a moraine above ice, 100, 120 and 163 m. on a glacier, Zivolka Fjord 15 m. on a glacier and 30 m., near Cape Borisoff 80—95 m., Admiralty Peninsula 115 m., Arkhangel Bay 40—50, 110—118, 140—150, 157, 172, 182, 192, 235 and 239 m., north of Arkhangel Gl. 145—160 m., south of the gl. 195 and 200 m. Besides these finds

this species has been found in morainic matter on Arkhangel Gl. to 130 m., and on Litchutin Island to 100 m.

12. *Acmæa testudinalis*, Müll.: Krestovii Fjord near the present sea level, probably recent.
13. *Tectura rubella*, Fabr.: Matotchka Valley 120 m. and Belushii Bay 130—142 m.
14. *Margarita* sp.: Belushii Bay 50—52 m.
15. *Bela trevelyana*, Turt. var. *novaja-semljensis*, Leche: Matotchka Valley 65—70 m.
16. *Buccinum undatum*, Lin.?: Krestovii Fjord and the northern Krestovii Island near the present sea level.
17. *Buccinum grønlandicum*, Chemn.: Krestovii Fjord near sea level and Berkh Island to 50 m.
18. *Neptunea* sp. (despecta?): Matotchka Valley 120 m.
19. *Fusus fornicatus*, Reeve: N. Goose Cape.
20. *Balanus* sp. fragments: Matotchka Valley 65—70 and 120 m., Belushii Bay 100—115, 130—142 m.; Mashigin Fjord 40—85 m., Zivolka Fjord 15 m. in gravel on the ice, and Berkh Island 50 m.
21. *Natica clausa*, Brod & Sow, in several places in the present sea level.

For the *Astarte* species found the nomenclature of AD. S. JENSEN has been used (37). Most of the localities mentioned above are to be found in the map, pl. XXVI.

There is reason to believe that both the glaciation and the melting of the ice sheets were going on at the same time and nearly in the same way in Novaya Zemlya, Frantz Joseph Land, Spitsbergen and Greenland. It is known that Frantz Joseph Land once has been more heavily glaciated than now, and strongly submerged too, for shore-lines have been observed to great heights above sea level. Bones of seals have been found to 210 m., and water-worn pebbles to 333 m. a. s. l., but any report based upon a closer survey of the land as to its quaternary geology has not been published.

In Spitsbergen a series of expeditions have been at work, and also the quaternary conditions have been studied, especially by NATHORST, G. DE GEER, B. HÖGBOM, HOEL, WERENSKIOLD, HOLMSEN and NANSEN. The strandflat has been dealt with and discussed by DE GEER, HÖGBOM, HOEL, WERENSKIOLD and NANSEN, the glaciation by HÖGBOM, HOEL, WERENSKIOLD and DE GEER, the shore-lines especially by HOEL and WERENSKIOLD, who by levellings have determined a number of lines both on the north-west coast, on the coasts of the Ice Fjord, and along the coast south of this fjord towards South Cape. All the evidences at hand are of importance when a correlation is to be attempted between Spitsbergen and Novaya Zemlya, but of the greatest value are undoubtedly the shore-lines, if granted that the shore-lines mark climatic conditions that may have prevailed at the same time throughout the whole arctic region.

According to Hoel (22—26) and Werenskiold (77, 78), and a letter from Hoel of 21. March 1923, shore-lines have been measured in Spitsbergen, on the mainland, at 15, 27, 35, 54, 77—80, 105, 120—123, 150, 180—200, 220, 335 and 340 m. a. s. l. Quaternary strand marks higher than 340 m. have never been observed. Hoel states that the heights of the shore-lines are remarkably constant in the different places on the coasts, and do not rise inwards along the fjords as in Norway. Prince Charles Foreland makes an exception, as it seems to have been displaced in relation to the mainland in late Quaternary times.

The highest situated terraces and shore-lines have been found near the South Cape, but also on the west coast farther to the north, at Quade Hook, ledges have been found 200—250 m. above the sea. Nansen measured in Liefde Bay three shore-lines at 11, 27, and 41 m. a. s. l., and in Lake Valley he found four shore-lines 11, 24, 30,8, and 46,8 m. The figures given by Hoel and Werenskiold must be regarded as average values, as the material collected during a series of expeditions has not yet been worked out into detail. The elevation 150 m. refers to a plateau at Ebeltoft Harbour about one km. wide, and 190—200 is the height of a platform on the southern side of the Wille Mountain (78).

The northeastern coast of Greenland has been submerged to about 400 m. as reported by Koch (39, p. 441), that is a submergence of about the same size as that of Novaya Zemlya and Spitsbergen. North-east Greenland has been submerged to about the same depth. According to Feilden, Grinnel Land has been submerged about 1 000 feet below the present level (3), and he found *Mya truncata* in "various places in fossil deposits from 40 to 800 feet above sea level" (3, p. 500). Schei found several terraces in the inner part of Foulke Fjord (78°,20 north latitude) the lower at about 24 m., the higher estimated to 100—125 m. a. s. l. In Hayes Fjord, Grinnel Land, three shore-lines were observed and measured by aneroid 95,1, 133,6 and 174 m. (571 feet) a. s. l. In Bedford Pim Island terraces were found 50 and 105 m. a. s. l. The highest shore-line lay 120 m. (394,5 feet) above the sea. Near Cape Rutherford six shore-lines were observed. "As to their elevation definite figures can be given for nos. 3 and 6, the former lying 22,5 m., the latter 117 m. above sea level." At Jones Sound the highest marine terrace was found at the head of Goose Fjord 466 feet (142 m.) a. s. l. (27).

Along the eastern shores of Baffin Island terraces were observed, estimated to 500—700 feet a. s. l., according to the report of A. P. Low on the cruise of the "Neptune", and "the same height is given for terraces on the western side of Hudson Bay, while at Cape Wolstenholme, on the south side of Hudson Strait, the terraces rise to 800 feet" (260 m.) (l. c. pp. 24—25).

The submergence seems to be decreasing from the northern Greenland and Grinnel Land to about Jones Sound, and from there it is increasing to the south towards the centre of the northeastern glaciation of the North American Continent.

From Foulke Fjord the submergence of the west coast of Greenland is steadily decreasing to the south. STEENSTRUP found a terrace 150 m. a. s. l. at Kingua at the head of Uvkusigsak Fjord (72° 24′ N. L.), but many lower shore-lines were to be seen (70, p. 230). On the west coast of Disco Island at Kugsuak he measured terraces at 79,3, 53,9, 28,5 and 7,7 m. a. s. l., and east of Skandsen on the southeastern side of the island he measured terraces at 88,7, 49,4, and 26,3 m. a. s. l. (l. c. p. 231). These levels have been found in many places with nearly the same heights. At Isortok Fjord (67° 12′ N. L.) three terraces have been measured at 91,1, 69,6 and 15,8 m. a. s. l. In a valley near Mount Ilivertalik (64° N. L.) KORNERUP measured five terraces at 8,5, 17, 29, 59, and 101 m. a. s. l., but these figures do not refer to the corresponding shore-lines (40 and 41 pp. 99—100). Farthest to the south the submergence has been about 100 m. (58, p. 343), and it is therefore of the same size as that of Iceland.

The central part of the Fennoscandian depression, accompanying the last great glaciation, seems to have been nearly of the same size as the depression of the said arctic islands, but the northern and northwestern coasts where shore-lines are most distinctly developed have been rather little depressed compared with the coasts of the arctic islands, on account of their situation near the extremity of the depressed area. According to TANNER (74) the uppermost shore-line I α lies in Kildin, the western part of the Murman Coast, 90 m. a. s. l., and in the Varanger Peninsula it ascends from 75 m. at Makur on the north coast to 90 m. at Krampenes near Vadsø on the south coast. Farther to the west it cannot be pointed out, as the border of the inland ice passed beyond the outer coast line (l. c. fig. 9, p. 103). Below this line is a line I β about 58 m. at Makur, ascending to 80 m. at Krampenes (l. c. Tafl. 3). When this shore-line was engraved several places on the coast to the west had been left uncovered by the inland ice (l. c. fig. 10, p. 104). A third shore-line I γ rises from 45 m. at Makur to 70 m. at Krampenes (l. c. Tafl. 3).

The first shore-line that can be followed continuously to the heads of all the Fjords of Finmark Fylke is I ε rising from 35 m. at Makur to 60 m. at Krampenes, and to 78 m. at Sandnes in South Varanger. Along the Porsanger Fjord it rises from 23—24 m. at the entrance to 65 m. at the head of the fjord. From this level several occurrences of shells are known, containing only arctic species. When this shore-line was engraved, the ice border had retired to the inner table land, leaving all the fjords free from ice. Below these shore-lines some other lines have been observed in a few places, but they have not been measured.

Besides the shore-lines above mentioned there is a line II A ascending from 10 m. at the entrance and to 30 m. at the head of Porsanger Fjord. Close below this level a mollusk fauna has been found containing a fairly great percentage of boreal mollusk species, showing that a milder climate had prevailed for some time during the rise of the land from this level.

In Troms Fylke farther south, in many places between Kvænangen Fjord and Ofoten Fjord, several raised beaches and shore-lines have been observed, which undoubtedly correspond to the levels I α—I γ, pointed out by TANNER in Finmark, but these levels have neither been so closely surveyed, nor the material collected so completely worked out that a safe correlation with the levels in Finmark can be undertaken. Terminal moraine ridges cross the outer part of the Lyngen Fjord, Tromsø Sound at Tromsø, Maalselv Valley at the Malangsfoss and the Salang Valley at the head of the Salang Fjord. These moraines mark a well defined stage in the recession of the last inland ice, which may be called the Fjord Stage. At that time the land was submerged to about 70 m. at Tromsø and to 110 m. at the Malangsfoss 25 km. from the head of the present fjord. This level is asumed to correspond to I β in Finmark. As the said moraines generally consist of two ridges, and as the site of the moraine series seems to allow such a conclusion, it has been presumed that this stage corresponds to the Ra-Salpauselkä Stage of southern Fennoscandia (15 and 16).

The best developed shore-line is the one described by BRAVAIS, HELLAND, VOGT and others as "the uppermost shore-line", preliminary called the M-shore-line by the present author. When this shore-line was engraved, the fjords were free from ice, but valley glaciers, as a rule, entered the heads of the fjords. The land was submerged to 44 m. at Tromsø, to 60 m. along the Tjell Sound, to 80—90 m. at the heads of the great fjords Lyngen and Balsfjord, and to above 100 m. below the present sea level in the upper part of the Maalselv Valley, which at that time was a fjord. Terminal moraines crossing the mouths of all the greater side valleys show how far the valley glaciers were advanced. This stage of the retiring inland ice may be called the Valley Stage (15 and 16).

The M-shore-line corresponds undoubtedly to the shore-line I ε in Finmark, among others proved by the fossil mollusk fauna.

To the shore-line II A of TANNER in Finmark corresponds a well developed shore-line in Troms Fylke, described as "the lower shore-line" by HELLAND, VOGT and others and by the present author called the T-shore-line. On account of the mollusk fauna in the shell banks that are to be found in several places, especially along the Tjell Sound and the Tromsø Sound, it must be quite safely concluded that this shore-line corresponds to the *Tapes-Littorina* level in the southern part of Fennoscandia. It is situated at an elevation of about 40 % of that of the M-shore-line (16, 17).

But between the levels M and T in Troms Fylke two more shore-lines have been pointed out, called M_1 and M_2. M_1 is situated at about 80—84 % and M_2 at about 60—64 % of the elevation of M. To these shore-lines correspond two moraine series in the valleys. Previous to a stopping of the rise of the land a stopping of the recession of the ice or a small advance of the valley glaciers took place on account of unfavourable climatic conditions. The two shore-lines just mentioned have also been observed in Finmark in a few places by TANNER (74, III p. 126), but as they have not been measured, they must have been faintly developed, and not to be followed continuously. As they have, in Troms Fylke, mostly been engraved in loose material, it may be that there along the rock coast of Finmark was too little loose material to allow their development, but it is, however, thinkable that the melting of the ice went on more continuously there, because the accumulation of snow in the winter months was less, and the summer months were relatively warm.

Along the eastern border of the Fennoscandian ice sheet no important stopping of the recession of the ice seems to have taken place, as no shore-lines have been reported. Not even during the time of the strongly engraved M-line does the ice recession seem to have been brought to a stop there, but in southern Norway the Romerik Stage, moraines and shore-line, must have been formed during that time. The climatic conditions, which caused the stoppings of the ice recession and engraving of corresponding shore-lines, must therefore chiefly have prevailed along the western and northern coasts of Norway, reaching just east of the divide where shore-lines were developed along the shores of the ice-dammed lakes.

During the melting period that succeeded the time of the M_2-line the valley glaciers retired beyond the watershed, or melted away as dead glaciers in the valleys. The land began again to rise, at first under better climatic conditions than now, for many boreal mollusk species immigrated, which in the present time only are to be found farther to the south. The uplift of the land went on without any traceable stop nearly to the present sea level, but during the last part of the uplift, the climate had once more grown less favourable. Several boreal mollusk species retired to more southern latitudes according to the evidences of the shell banks, and in the valleys far inland glaciers invaded formerly ice free ground, and attained a considerable thickness, proved by moraine ridges in most valleys. This new increase of the ice cover did not only cause a stopping in the uplift of the land, but it was followed by a new sinking to the T-shore-line. During the first part of this sinking the climate was still relatively cold, for the marine fauna was poor in boreal species (30—35⁰/o). In that way elapsed the Atlantic time on the coasts of the Norwegian Sea and the Barentz Sea (15, III). In southern latitudes the climate of this period was mild and moist (cp. papers by Blytt, Sernander, Brøgger, Øyen and more authors).

The northern part of Nordland Fylke between Salten Fjord and Ofoten Fjord is an intricate district with numerous islands, necks and long fjords with many branches penetrating far inland near to the frontier. To the north it has been visited by Hoel, who measured several terraces and shore-lines (76), and Enquist has studied the cirques and the local glaciation of the land (6). Between the Salten Fjord and the Tys Fjord Rekstad has accomplished the geological mapping of the greater part of the area, and during this work he had measured a series of terraces and shore-lines that seemed to represent more levels than formerly known (62, 63, 64). As the district is bounded by the sea to the west, by the Svartis Peninsula with its glaciers advancing far down, to the south, and by the highest mountain region of northern Scandinavia to the east, it was to be expected that a closer survey of the shore-lines would be of some importance. On that account the present writer carried out, in the summer of 1923, a series of levellings, 33 in all, within the Folla district, north of Bodø, between the outer coast line and the heads of the fjords. The levellings were performed with great care on the best localities that were to be found. Twelve shore-lines could be pointed out, at 3,1, 7,4, 14,9, 22,6 31,8, 41,1, 53,2, 61,2, 70,2, 77,3, 84,7 and 99,2 m. a. s. l. As the gradients are very small, for the 99,2 m. line only 0,30—0,40 m. pro km., and for the lower levels quite inconsiderable, the figures given above are the arithmetic means of the figures found by direct measuring. In that way the inevitable measuring errors may be nearly eliminated. The 99,2 m. line is the same as the M-line in Troms Fylke. It has formerly been pointed out by Hoel and Rekstad (cp. a map by Rekstad 1922, 65). The 84,7 m. line and the 61,2 m. line are supposed to be identical with M_1 and M_2, and the 41,1 m. line is identical with the T-shore-line in Troms Fylke.

It must be assumed that the same favourable climatic periods, which caused melting of the ice with a subsequent uplift of the land in northern Fennoscandia, also reached as far into the arctic region as Novaya Zemlya and Spitsbergen, and that cold and moist periods that stopped the melting of the ice, or brought about an advance of the glaciers with a following stopping of the uplift of the land and engraving of shore-lines also reached over there. This assumption must be made, when a correlation is to be attempted, and if this assumption does not hold good, a correlation would be without any base. The following attempt at carrying out a correlation is therefore based on the supposition of the changes being contemporaneous in these different countries, and has as its starting point the idea that to a shore-line in Norway there is to be found a corresponding shore-line in Novaya Zemlya and Spitsbergen.

It should seem likely that the ice border should be more strongly attacked by the melting effect of the sea water along the coast of northern Norway than along the west coast of Novaya Zemlya, or the southern coast of Spitsbergen, and if so the uppermost, shore-lines on the coast of Finmark Fylke would be somewhat older than the uppermost shore-lines on the coasts of the said arctic islands, but on the other hand, the ice along these coasts was attacked on a broader front, not protected against the force of the sea by islands and islets. It is also thinkable that the Norwegian glaciers were better supplied by new ice than the glaciers of Novaya Zemlya and Spitsbergen, on account of a greater humidity on the coast of Norway. The oldest shore-lines may therefore be of nearly the same age on all the coasts in question.

In the subjoined table, in which the correlation is accomplished according to the assumptions above mentioned, the shore-lines likely to be of the same age have been inserted on the same line, with the heights given both in metres and in percentage of the mean elevation of one of the shore-lines chosen as main line. As main line for Novaya Zemlya the 121 m. line has been chosen for the levels VII—XVII, because it is to be found everywhere, and is better developed than most of the other shore-lines, and therefore has been more exactly measured. As main line for the levels VI—I another perfect shore-line has been used, the shore-line VI. The inserted figures are the arithmetic means of the figures found by measurements along the west coast, where the elevations of the shore-lines vary only little with the latitude. It will be seen that the figures in the table do not deviate much from the figures found by direct measuring. This method has been used in order to get figures fit for an synoptic table.

As for the shore-lines of Spitsbergen the figures found in the literature at hand or in the above mentioned letter from HOEL have been inserted directly. These figures are to be regarded as mean values preliminary reported, as the material has not yet been worked out into detail. The figures for Novaya Zemlya and Spitsbergen are nearly of the same size, and can therefore be directly compared.

As to northern Norway the shore-lines there are not elevated enough to admit a direct comparison, and besides that, they ascend inwards along the fjords. Figures for the purpose of comparison have therefore been computed by taking the arithmetic means of all heights found by levellings of the different shore-lines within a relatively great area. For the Lyngen-Ulsfjord district inside the ordinary fairway are found as a mean of 35 levellings: $M = 64{,}1$, $M_1 = 53{,}5$, $M_2 = 42{,}1$, $T = 24{,}6$ and $T_1 = 11{,}3$ m. Figures of nearly equal size have been found by direct levelling at Hammervik close inside the Lyngen terminal moraine south of Havnes, namely $M = 64{,}4$, $M_1 = 53{,}7$, $M_2 = 42{,}6$, $T = 25{,}1$ and $T_1 = 11{,}6$ m. For the Malangen district inside the fairway have been found by a similar compution as a mean of 11 levellings: $M = 64{,}7$, $M_1 = 53{,}6$, $M_2 = 39{,}9$, $T = 24{,}4$ and $T_1 = 12{,}6$, and by direct levelling have been found at Nyheimen near Maalsnes: $M = 64{,}4$, $N_1 = 53{,}4$, $M_2 = 39{,}7$, $T = 24{,}4$ and $T_1 = 12{,}9$ m. For the Folla district the figures of twelve levels between 3 and 100 m. have already been given, but above these levels two higher levels have been pointed out, the one between 120 and 130 m., the other between 140 and 150 m. The corresponding means are 124 and 148 m. The former is a sure marine level, as shells have been traced to 120 m. above the sea in a single place (Mjelde) south of Kjerringøy, but the level has only been observed in 7 localities, and the figures found are not at all sure.

As main line for Troms Fylke and Nordland Fylke the M-line has been used, and for Finmark Fylke I ε, as these lines are identical. Apart from the two elevated lines 124 and 148 m. a. s. l. in Nordland Fylke, the shore-lines above the M-line have not been so closely studied south of Finmark that they can be taken into account here except as scattered observations. In Finmark these elevated shore-lines, however, have been surveyed by TANNER (Bulletin Comm. Geol. de Finland vol. III and IV). I α has been pointed out in 18 places on the north coast of Varanger Peninsula at elevations between 70 and 81 m., the arithmetic mean of which is 75,5 m. I β has been measured in 7 places on the same coast at elevations between 55 and 66,5 m., mean 60,6 m., I γ has been measured in 17 places between 38 and 58,5 m., mean 48,4 m., and I ε has been measured i 16 places at elevations between 28 and 47,5 m., mean 38,2 m. $I\alpha \cdot 100 : I\varepsilon = 197{,}6$, $I\beta \cdot 100 : I\varepsilon = 158{,}6$ and $I\gamma \cdot 100 : I\varepsilon = 126{,}7$. Nearly the same figures have been found for the locality Havningberg by using the figures found by measuring, namely 198,7, 153,8 and 128,6 and for I β and I γ at Mys Bykoff (Kildin), namely 153,0 and 132,7. The computed means have been inserted in the table, and their ratio to I ε.

The 54,4 m. line in Nowaya Zemlya and the 54 m. line in Spitsbergen have been assumed to be contemporaneous with the T-line in Troms and Nordland Fylkes, and the line II A in Finmark Fylke. Just before this line was engraved, an advance of the glaciers had taken place succeeded by a sinking of the land, at all events along the western and northern coasts of Norway, as an effect of the great humidity of

Folla			Lyngen			North Varanger			Novaya Zemlya			Spitsbergen		
Line	Metre	100 L./m*	Line	Metre	100 L./m*	Line	Metre	100 L./m*	Line	Metre	100 L./m*	Line	Metre	100 L./m*
-	-	-	1	L = 99,4 m = 50,8	195	Iα	75,5	197,6	XVIII	240	198,0		240?	195?
-	-	-	1	L = 89,1 m = 50,8	174	5	-	-	XVII	215	177,7		220	178,7
-	148	149	1	L = 78 m = 50,8	153	Iβ	60,6	158,6	XVI	198	163,6		200	162,6
-	-	-	2	L = 67,8 m = 46,8	143,6	6	-	-	XV	175,9	145,4		180	146,3
-	124	125	3	L = 67,4 m = 54,5	123,6	Iγ	48,4	126,7	XIV	159,5	131,8		> 150	> 122
-	107,5	114	4	L = 87 m 75,8	114,8	Iδ	-	-	XIII	137,5	114		-	-
XII	99,2	100	M	64,1	100	Iε	38,2	100	XII	121	100		123	100
-	-	-	-	-	-	Observed by TANNER	but not measured (l.c. III, p.176).	-	XI	114	95		-	-
XI	84,7	85,4	M₁	53,5	83,5			-	-	107	88,4		105	85,4
-	-	-	-	-	-			-	X	101	83,7		-	-
X	77,8	77,9	-	-	-			-	-	92?	76,0		-	-
IX	70,2	70,8	M₂	42,1	65,7			-	IX	82	67,6		77—80	> 62,6
VIII	61,2	61,7	-	-	-			-	VIII	71	58,7		-	-
VII	53,2	53,6	-	-	-			-	VII	62	51,2		-	-
VI	41,1	100	T	24,6	100	II A	17	100	VI	54,4	100		54	100
V	31,8	77,4	-	-	-	-	-	-	V	42,6	78,7	7	41—46,8	> 76
IV	22,6	55	T₁	11,3	45	-	-	-	IV	31,8	58,3		35	64,8
III	14,9	36,3	-	-	-	-	-	-	III	22,2	40,8		27	50,0
II	7,4	18,0	-	-	-	-	-	-	II	12,7	23,3		15	27,8
I	3,1	-	-	-	-	-	-	-	I	3,1	-		-	-

* m is the main line.

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[1] These figures have been found by levelling at Eidstrand about 10 km. southwest of Lyngstua. The shore-lines in this locality lie in a rather open situation, and as they are excellently developed, they are easily seen from the fairway. Besides the three lines inserted in the table, two excellent lines have been measured 118 and 136 m. a. s. l. The ratio 195 has else been found in several places (15, II, p. 230), and 152—156 in 7 places, mean value 152,6 (l. c. p. 229).

[2] The inserted figures found by levelling at Jegtvik to the east of Kaag-Sound south of Skjervøy, 140—144 as well in a few places (l. c. 229).

the Atlantic time on the coasts of a still glaciated country. In the former chapters observations have been mentioned that suggest that similar conditions had prevailed on the coasts of Novaya Zemlya, and the same may have been the case in Spitsbergen too. The above mentioned shore-line marks the maximum of this sinking. If this assumption holds good, the lower shore-lines belong to a new period of upheavel of the arctic lands, and this shore-line has therefore been used as main line for the lower levels in the table.

According to what has been stated above, both in the table and elsewhere, the following parallels may be drawn between northern Fennoscandia and the arctic islands, especially Novaya Zemlya:

The Ice Age in question is the Mecklenburgian. Mighty glaciers filled all fjords and sounds of northern Norway, calving into the open sea off the outer coast line, but not confluent to a continuous ice barrier, or ice wall into the sea, except along the coast east of North Cape to the White Sea (59). The thicknes was about 600 metres above the present sea level in the outer part of the Folla district (according to observations 1923), in the Lyngen district 300—400 metres, and farther to the north no doubt considerably less. The arctic islands were strongly glaciated, and surrounded by continuous ice barriers. Depression unknown. Bear Island glaciated and depressed, but a greater part of the Barentz Sea free from ice.

Then the melting period set in:

a) The ice barrier of Novaya Zemlya was broken at Cape Britwin. The land was depressed to 370 m., and the uppermost flats were levelled, and shore lines engraved by the sea.

b) Between Bessimyannii Fjord and Gribovii Fjord shore-lines were engraved in more levels 350—300 m. above the sea. The ice barrier was broken at South Cape (Spitsbergen) and at Arkhangel Bay, and the Ulsfjord-Lyngen Glacier had parted into an Ulsfjord Glacier and a Lyngen Glacier. Tromsø Sound was barred by a great Balsfjord Glacier.

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[3] The figures are mean values from 11 localities along the fairway between Gibostad and the Lyngen Fjord (l. c. p. 219).

[4] The figures found at Sørfjordbotn near Kjeianes, Malangen. At Skutvik, Malangen 72,1 · 100 : 64 = 115,8 has been found. This line is assumed to correspond to I δ on the Varanger Peninsula.

[5] TANNER has in a few places found a shore-line between I α and I β, for instance at Domen near Vardø (76 · 100 : 45 = 170).

[6] A line I β_1 has been pointed out by TANNER.

[7] Shore-lines levelled by NANSEN (49, p. 197—198).

c) A shore-line was engraved along the coast of N. Z. 240 m. above sea level. The ice barrier was broken everywhere along the west coast to the Gorboff Islands, but great glaciers filled all fjords and bays. The eastern part of the Varanger Peninsula was free from ice, and I α was engraved (map by TANNER). Tromsø Sound still barred.

d) In N. Z. a shore-line was engraved 198 m. a. s. l. The fjords on the west coast were free from ice, but Matotchkin Strait was still barred between Pomorskaya Bay and to the east of Belushii Bay (cp. Pl. XXVII). A greater part of the Varanger Peninsula was free from ice and I β was engraved. In the Folla district the glacier has retired from the outer part of the fjord. The Ra-Salpauselkä Stage? (16). Now the Tromsø Sound was opened.

e) The middle part of Matotchkin Strait still barred by a glacier. The 159,5 m. line was engraved. The ice had retired from the outer coast line of Finmark, but the inner parts of the fjords were still filled by glaciers; I γ was formed. In the Folla district the ice yet filled the inner fjord branches.

f) Matotchkin Strait had been opened, and the 121 m. line was engraved. In Finmark the ice had retired to the inner table land. All fjords and main valleys in Troms Fylke and Nordland Fylke were free from ice, and the main valleys were for a greater part drowned, forming long and narrow fjords. All the side valleys in Troms Fylke were still filled by glaciers, and a well defined shore-line was engraved, the M-I ε-line.

g) During the following time the climate was steadily improving, only with small interruptions. The ice retired east of the divide, and the time of the ice-dammed lakes set in. Only in some valleys in Troms Fylke off-shoots from the inland ice were still to be found. After a short stand-still at a moraine series, these off-shoots retired beyond the frontier, and the land rose from the M_2-shore-line nearly to the present level. In N. Z. the ice cover retired inside its present limits (the Boreal time).

h) The humid climate of the Atlantic time proved to be less favourable along the arctic coasts, for new glaciers came into existence in the mountain regions of northern Norway, and the ice cover of N. Z. was increasing. In the Alps probably the moraines of the Gschnitz Stage were deposited at that time (57 and 8, p. 295). The land again began to sink (the *Tapes-Littorina* sinking), peat layers were submerged and buried below younger marine sediments, for instance a layer about 12 m. a. s. l. south of Andenes, Andøy, a layer in the town of Tromsø 15 m. a. s. l. buried between layers af gravel and shell fragments, and probably the lower horizon with organic remains below clay found by the Russian expedition in N. Z. During the last part of the period of sinking the climate grew steadily better, and when the shore-line that ended the sinking period was engraved (the T-line, IIA in Finmark, the 54,4 line in N. Z.), and during the first part of the rise of the land from this line, the climate was better than ever before. During that time *Mytilus edulis* probably immigrated to Spitsbergen as the 54 m. line seems to be its upper limit there (cp. HOEL and HÖGBOM).

i) The climate became once more unfavourable. Glaciers advanced both in northern Norway and in Novaya Zemlya, and a sinking set in to a new shore-line (T_1-line in Troms Fylke, probably the 31,8 m. line in N. Z.), drowning peat bogs in many places: on the western side of the Tromsøy 2,2 m. a. s. l. (16, p. 13), at Ramsaa on Andøy (80, p. 106), and at Skagen in the southwestern part of Langøy, Vesteraalen. There the following profile was found in 1920 in a cellar between 5,18 and 7,33 m. a. s. l.:

1. Surface layer of peat	0,40	cm.
2. Layer of sand and gravel In the lower part of the gravel were cobbles and pieces of drift-wood.	0,70	„
3. Layer of peat	0,15—0,35	„
4. Sand and gravel with cobbles and a log of drift-wood	0,70	„
5. Rock detritus at the bottom.		

From the cellar ran a ditch towards the sea, and in the ditch the peat layer thinned out and disappeared 16 m. from the cellar wall about 4,90 m. a. s. l. The T_1-shore-line lies 6,5 m. above the present shore-line in this locality. The upper horizon with peat found in Novaya Zemlya is assumed to date from this time, and probably the Daun Stage in the Alps (57 and 8, p. 304).

k) The Iron Age. The islands outside the fairway and the coasts of Finmark are emerged nearly to the present level. Axe-marked logs were washed ashore in N. Z. at 22,2 m. a. s. l. The land between the Svartis Peninsula and Ofoten Fjord still depressed to the 14,9 m. line. Near Rognan, Salten, an iron anchor was buried below sand 14 m. above the present sea level (14, pp. 183—184).

l) The Folla district depressed to 7,4 m. and N. Z. to 12,7 m. Masses of drift-wood floated ashore along the coasts of N. Z. This is supposed to have taken place only a few centuries ago. *Mytilus edulis* immigrated to N. Z.

As to Spitsbergen, it is to be expected that a detailed working of the material collected will show that the whole development has taken place in a similar way as in Novaya Zemlya. The material at hand from Greenland and the northwestern America seems to show a parallel development of these lands too, but it is too scattered and heterogeneous to be taken into account in the table (4).

V. SOME CLOSING REMARKS.

It is highly probable that Novaya Zemlya during the greater part of Mesozoic and Tertiary times was a continuous highland, much elevated above the surrounding seas. While in Spitsbergen Mesozoic and Tertiary rocks have a great extension, no rocks of Tertiary Age have been observed in Novaya Zemlya, and rocks of Mesozoic Age have mainly been found as erratic blocks. If such younger rocks at any time had a noteworthy extension there, one should expect remains to have been left in considerable areas, for in Novaya Zemlya the glacial erosion cannot have been greater than in Spitsbergen, since they have been covered by ice sheets of similar dimensions. But to judge from the fact that on the eastern side of the neighbouring Ural Range a wide plain of abrasion has been covered by Tertiary layers showing a lower stand of the land there at that time, it is probable that Novaya Zemlya as well has been situated somewhat lower than now. Tertiary layers may have been deposited on land areas now broken down by the sea, or, if deposited within the present land area, they must have been taken away by the ice (42, p. 441).

It is possible that NANSEN is right in saying that "in pre-glacial times, the bottom of the Barents Murman Sea was elevated into dry land" (47 p. 33) but if so, Novaya Zemlya cannot have been elevated much above the present sea level for any great length of time, for on the charts no submarine valleys can safely be pointed out, and most fjords seem to be shallow, with a hard bottom, probably not consisting of loose material of any kind. On the contrary, the wide continental shelf surrounding the steeply rising highland with rock layers often dipping nearly vertically seems to indicate that the former stand of the sea has not, as a rule, been very much different from what it is now, and therefore a greater part of the original mountain range may have been broken down by the sea than by running water, or other agencies.

HÖFER observed from Wilczek Spitze a series of summits to the north, northeast, south and southeast being nearly of the same level (31, p. 300), and during the summer of 1921 this fact was noted as a characteristic feature of the morphology of the central part of the country. This top level can scarcely be explained by assuming it to be an old plain of abrasion, or a peneplain. Such a top level may to some extent be of a primary origin, but it is more likely a result of the ordinary weathering. The sides of mountains, if not too steep, would soon be covered by the loose material, often overgrown with vegetation, while the tops lie bare and exposed to the varying temperature and humidity, and frequent hard gales that take away the detached rock detritus successively. In this way the most elevated summits within a mountain region may lose masses of material every year, while the lower ridges and tops are only faintly altered. If an arctic climate prevails, this levelling work would increase, as the lower land is covered and sheltered by the frozen earth, and the frost action on the bare rocks is added as an agency. The higher and steeper the mountains, the greater is the rock surface exposed to the weathering, and the more effective the forces that act upon them.

The plateau surface, including the greater part of the southern island and the peninsulas between the fjords and bays farther to the north, often cuts the rock layers at nearly a right angle and is consequently of a secondary origin. It should seem to be an obvious conclusion that the coasts of an island as Novaya Zemlya, consisting of weak rock layers and exposed to the force of an open sea, would be so quickly broken down by wave action that the land would rise from the shore-line in high cliffs so rapidly undermined that the rivers must enter the sea through narrow canyons, or by falling down from the mouths of hanging valleys. Instead of levelling the land the rivers more likely were dissecting it, the more so, because the sea worked on relatively weak rock layers, while the rivers, especially their head waters, were working on harder metamorphic rocks with some igneous material. Therefore a development of a peneplain by river action is utterly improbable in a land as Novaya Zemlya, even if the sea level could be assumed to have been constant for a length of time. If the plateaus should have been levelled by the sea, the land must have been depressed to between 300 and 600 m. below the present sea level. The outer parts have in many places been submerged below the surface of the sea after the recession of the last ice sheet, and it is possible that the land once has been submerged still more after the melting of a former ice sheet, but there is no evidence to support such a suppositon, and the higher plateaus are not at all so even that a levelling by the sea is probable. It is therefore more likely that the forming of these plateaus is due to the action of the great inland ice (or ices) that once overflowed the land, after a long preparatory work through weathering, winds and to some extent through river action above local base levels, had taken place (cp. Ahlmann, 2, pp. 643—644). A plateau levelled in that way may be called a glacial peneplain.

Sundry forms of glaciers have their particular way of working. A cirque glacier sinks a bowl-shaped "botn" in the underlying rocks, a long glacier tongue, compelled to make its way between mountains, which it cannot overflow, widens and deepens its bed in forming a trough valley with a "botn" at its upper end, and an off-shoot, from an inland ice passing a watershed, would form a saddle-shaped defile etc., but in what manner does a great ice sheet, thick enough to fill all the valleys and overflow all ridges and mountain tops, work?

A great ice sheet of such a thickness as that of Novaya Zemlya must be supposed to move from the ice divide more or less in a direction normal to the longitudinal axis of the land. All the valleys parallel to the divide would be filled by ice and ground-moraine. Narrow preglacial valleys, often crooked, here parallel, there perpendicular to the divide, might only be eroded by the moving ice if their direction did not deviate too much from the direction of the ice movement. The lower part of the ice, filling valleys and other depressions, would move relatively slowly compared with the upper part, above most of the hindrances. These ice masses forming a continuous ice flow hundreds of km. wide, may not have had any tendency to dig out valleys or troughs, especially if they united outside the land border, for then the movement of the ice in valleys and fjords would be checked by the barrier ice off-shore. In short, during this stage the erosive power of an inland ice may mostly have been applied in levelling the underground by grinding away tops and ridges that may rise in its way above the medium level. Fjords and valleys may chiefly have been dug out by isolated glacier tongues, before a glaciation had grown into a continuous inland ice, and after the broadly eroding ice sheet had melted away.

It seems to be a fact that the greater part of land areas once covered by an inland ice of heavy dimensions have been more or less levelled by the ice, both near the ice divide and in the peripheric parts. The preglacial surface of western and northwestern Norway was undoubtedly very uneven, dissected by rivers into a confused highland with narrow gorges, steep overhanging mountain walls and sharp ridges and tops, as the rocks along the coasts, where the sea was at work, were relatively hard compared to the rocks in which the rivers generally were working, but even there the levelling effect of the inland ice has highly prevailed, for notwithstanding the different hardness of the rocks and the tectonical irregularities, the peninsulas between the fjords and the mountain parties between the valleys have been smoothed and levelled, and the traces of the work of the ice are of a much more grand aspect and better conserved there than in the valleys, where glaciers have been in action for a long time after the recession of the last continuous ice sheet. This work has been done in spite of the fact that the ice flows that levelled western and northwestern Norway on their way from the ice divide had to pass relatively high mountains before reaching our country, and therefore seldom were large enough to form an ice barrier off the coast, or even to form a continuous ice sheet all over the land. In Novaya Zemlya, Kola and the greater part of Finmark even the last inland ice seems to have formed a continuous ice sheet, and as the rocks were weaker or more homogenous than in western Norway, the levelling has been more perfect and uniform there.

According to a sketch map and a block diagram of the valley of Vaala River with environs by WERENSKIOLD (78, pp. 362—363), a similar levelling seems to have taken place in the central part of Norway. In the Alps on the contrary the state of things must have been different, for according to PENCK and BRÜCKNER the ice masses did never surpass the valley glacier stage or a network stage. The Alpine glaciers therefore only deepened and widened the valleys, and rounded the hills and knolls at lower levels, but the lofty peaks and ridges were left to be worn down by the weathering.

As to the strandflat that surrounds most of the arctic coasts NANSEN is of the opinion that it "has been developed chiefly during interglacial periods with cold climates, and especially during the very cold time preceding each glacial period, and during its first part, before the outer coast was covered by the inland ice, and as long as the level of the shore-line still remained nearly stable" (49, p. 47). A great glaciation setting in and followed by a sinking of the land should seem quite eminently to bring about the conditions necessary for the forming of a strandflat, and it is highly probable that the strandflat of Novaya Zemlya was originally formed under such conditions in an interglacial period. When at present the preserved remains of this strandflat are not to be found so even and regular as should be expected from a flat formed by the sea, it is owing to the circumstance that the last inland ice has played a part in the final modelling of it, especially along the northern parts of the coasts.

The present elevated situation of the strandflat must be due to altered isostatic conditions after its forming, on account of a more recent denudation of the land surface by ice and running water.

Tromsø, December 1923.

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Explanation of Plates.

Plate I.

Fig. 1. The northern part of the Goose Land. In the foreground a shore-line, in the background to the left a low mountain wall with stripes of snow in some raised shore-lines. Lynge phot 5/7.

Fig. 2. A flat of morainic material (between the sea shore to the right and the inner part of the Goose Bay to the left) connecting an island with the mainland. Note the curving lines. Lynge phot. 4/7.

Fig. 3. A ditch running inwards from the sea shore across the flat on fig. 2. Lynge phot. 4/7.

Plate II.

Fig. 1. Panorama showing the south side of the Outer Basin of Mashigin Fjord, Fram Bay and Lynge Glacier from Mt. Nansen about 750 m. a. s. l. Lund phot. 10/8.

Fig. 2. Panorama of the eastern part of Bessimyannii Fjord, as seen from the north side. Lund phot. 31/8.

Plate III.

Fig. 1. The bottom of a former sound on the southern side of Gribovii Fjord 200 m. a. s. l. with shell fragments and pebbles. Grønlie phot. 29/8.

Fig. 2. Pomorskaya Bay and the lagoon. In the background the western part of the Strait towards Tchirakina Valley. Grønlie phot. 27/8.

Plate IV.

Fig. 1. Flat between Bessimyannii Fjord and Gribovii Fjord 350 m. a. s. l., on which rounded pebbles have been found. Note the shore-line in the background. Lynge phot. 31/8.

Fig. 2. A supposed shore-line 370 m. a. s. l. on the divide between Bessimyannii Fjord and Gribovii Fjord. Grønlie phot. 31/8.

Fig. 3. The flat of fig. 1 farther to to the north. Lynge phot. 31/8.

Plate V.

Fig. 1. Bakan Bay and Cape Stolbovoi seen from the east. O. Holtedahl phot. 7/7.

Fig. 2. A part of the cliff between Serebryanka Bay and the Strait. Grønlie phot. 22/7.

Fig. 3. Matotchka Mountain seen from the bay. Grønlie phot. 27/8.

Fig. 4. The head of the Serebryanka Fjord with the river delta. Mityoucheff Mts. to the left with cirque glaciers. Note the rounded contours of the mountains. Grønlie phot. 25/7.

Plate VI.

Fig. 1. The place where a brass tube was bolted down in the present shoreline of Pomorskaya Bay. Grønlie phot. 27/8.

Fig. 2. A local glacier on the western slope of Chalhonik Valley. A young moraine (grey) partly covers an overgrown ancientmoraine (black) in front of the glacier. Mt. Spører to the left. Grønlie phot. 13/7.

Plate VII.

Fig. 1. Strandflat at the southwestern promontory of Mityoucheff Mts. on the west side of Serebryanka Fjord. Lynge phot. 25/7.

Fig. 2. The western part of the Strait seen towards the S. W. from anchorage 4. Mt. Lasareff to the left, Lütke Mts. and Loshkin Mts. to the right. Lynge phot. 11/7.

Fig. 3. The strandflat on the north side of Krestovii Fjord. Lynge phot. 28/7.

Plate VIII.

Fig. 1. Mityoucheff Mts. seen from the eastern side of the Strait at anchorage 3. Note the low land between Serebryanka Fjord and the Strait. Grønlie phot. 10/7.

Fig. 2. A part of the Strait, bordered by lowlands on both sides, just northeast of Tchirakina Valley, seen from Lütke Mts. Grønlie phot. 9/7.

Fig. 3. An ice-worn branch of Chalhonik Valley seen from the west. Grønlie phot. 13/7.

Plate IX.

Fig. 1. Tretyakoff Glacier seen from Cape Morschewoi. Grønlie phot. 10/7.

Fig. 2. The Strait between Ekstam River and Baer Valley seen from the west. O. Holtedahl phot. 14/7.

Fig. 3. The land on the north side of the eastern entrance of the Strait O. Holtedahl phot. 20/7.

Plate X.

Fig. 1. The 204,8 metres shore-line on the south side of the eastern entrance of the Strait. Note the even plateau above the line. O. Holtedahl phot. 20/7.

Fig. 2. Eastern part of Zivolka Fjord seen from the north side. O. Holtedahl phot. 3/8.

Fig. 3. The calving front of Lacroix Glacier. Lund phot. 28/7.

Plate XI.

Fig. 1. The middle part of the Strait with the Tretyakoff Glacier in the foreground. Note the rounded mountain forms. Lynge phot. 12/7.

Fig. 2. The southern part of the Pankratyeff Peninsula. Lynge phot. 19/8.

Plate XII.

Fig. 1. The 3 m. and the 14,8 m. shore-lines in the moraine of the Lacroix Glacier. Grønlie phot. 3/8.

Fig. 2. The western flank of Økland Gl. Sliding of morainic material has bared the ice in some places. In the background the Blaafjell Basin. Grønlie phot. 4/8.

Fig. 3. The moraine-covered western border of Økland Gl. seen from the surface of the glacier. Grønlie phot. 4/8.

Plate XIII.

Fig. 1. Stone ice below moraine, 1 m. thick, in front of Lynge Gl. on the north side of the river. Grønlie phot. 10/8.

Fig. 2. A heap of fossiliferous gravel on Blaafjell Gl. 163 m. a. s. l. Grønlie phot. 2/8.

Plate XIV.

Fig. 1. The eastern part of Sol Bay. Loose material has been washed out. In the background an old cliff seems to disappear below the sediments to the left of the snow-drift. Grønlie phot. 24/8.

Fig. 2. Blaafjell Basin and Blaafjell Gl. seen from the northwest. Grønlie phot 2/8.

Fig. 3. Delta at the head of Straumsnes Bay. Shore-lines can be seen in the moraine of Plan Gl. In the background the mountains north of the Blaafjell Basin. Grønlie phot. 8/8.

Plate XV.

Fig. 1. Small sand ridges at the front of Boule Gl. Grønlie phot. 1/8.

Fig. 2. Sand terraces below the 15 m. level on the delta in front of Blaafjell Gl. Grønlie phot. 2/8.

Fig. 3. In the foreground a glacier river running on a bed of ice near the front of Blaafjell Gl. Grønlie phot. 2/8.

Plate XVI.

Fig. 1. The Norway ice plateau seen from W. side of Trollheimen Mts. Grønlie phot. 31/7.

Fig. 2. The western part of Ibis Gl. Parts of the extensive medial moraine are seen. Pakhtusov Mt. in the distance. O. Holtedahl phot. 4/8.

Fig. 3. Mountains north of Mt. Dietrichson. Dietrichson phot 29/7.

Plate XVII.

Fig. 1. Panorama showing Lacroix Gl., Økland Gl., Mt. Nansen, Plan Gl. and Lake Trehørningen etc. Lund phot. 4/8.

Fig. 2. Panorama showing Bremerhafen Mts., the Strait, Belushii Bay, and Syernaya Mt. Tyouleni Bay and Lake Lomvand in the middle part of the picture. Lund phot. 18/7.

Fig. 3. Panorama showing the coast between the Pankratyeff Peninsula and Arkhangel Bay seen from the eastern Cross (Krestovii) Island. Lund phot. 18/8.

Plate XVIII.

Fig. 1. A glacier river disappearing in a sink-hole near the northern border of the Pankratyeff Gl. Grønlie phot. 19/8.

Fig. 2. The canyon of the Ekstam River. Lynge phot. 14/7.

Plate XIX.

Fig. 1. Moraines a few km. northeast of Cape Borisoff. Grønlie phot. 23/8.

Fig. 2. A beach with rounded cobbles and shell fragments on the south side of Arkhangel Bay 239 m. a. s. l. seen from the east. Grønlie phot. 12/8.

Fig. 3. A log of drift-wood found northeast of Cape Borisoff. O. Holtedahl phot. 21/8.

Plate XX.

Fig. 1. The 62 m. line disappears below the right border of the Arkhangel Gl. about 4 km. from the sea shore. Grønlie phot. 17/8.

Fig. 2. An ancient cliff rising above the 54,4 m. line (here 59 m.) just north of the Arkhangel Gl. Grønlie phot. 17/8.

Plate XXI.

Fig. 1. A lateral river between the northern border of the Arkhangel Gl. and the ice-free land at the point where the glacier enters the lowland. Grønlie phot. 17/8.

Fig. 2. A part of the northern wall of the Pankratyeff Gl. showing the transition between the motionless ice and the ice in motion. Grønlie phot. 19/8.

Plate XXII.

Fig. 1. A river on the surface of the Arkhangel Gl. Grønlie phot. 17/8.

Fig. 2. Crevasses in Lacroix Gl. Lund phot. 30/7.

Plate XXIII.

Fig. 1. Neck of land connecting the Pankratyeff Peninsula with the mainland. To this place *Mytilus edulis* was found. The moraine covered part of the Pankratyeff Gl. to the right. Lynge phot. 19/8.

Fig. 2. Sand heaps washed by the sea on the "dead" part of the Pankratyeff Gl. 52 m. a. s. l. Grønlie phot. 19/8.

Plate XXIV.

Fig. 1. Arkhangel Gl. seen frem the N.W. (Litchutin Isl.). Grønlie phot. 16/8.

Fig. 2. Glacier to the northeast of the Pankratyeff Peninsula seen from a point on the latter 200 m. a. s. l. O. Holtedahl phot. 19/8.

Fig. 3. The inland ice seen from a crag at the northern border of the Arkhangel Gl. Grønlie phot. 17/8.

Plate XXV.

Fig. 1. Pebbles from different levels; A = Arkhangel Bay, B = Cape Borisoff, G-B = between Gribovii-Bessimyannii Fjords, Ø = the eastern entrance of the Strait. Soot-Ryen phot.

Fig. 2. A piece of drift-wood with an iron nail found on the front of the Pankratyeff Gl. 12 m. a. s. l. Soot-Ryen phot.

Plate XXVI.

Maps showing localities for levellings and aneroid measurements, isobases of various levels, and places where drift-wood and fossil shells have been found. The figures indicate the level in which the finds have been made in metres above sea-level.

Plate XXVII.

Diagram of the shore-lines along Matotchkin Strait with map of the Strait.

Plate XXVIII.

Diagram of the shore-lines along Mashigin Fjord with map of the fjord.

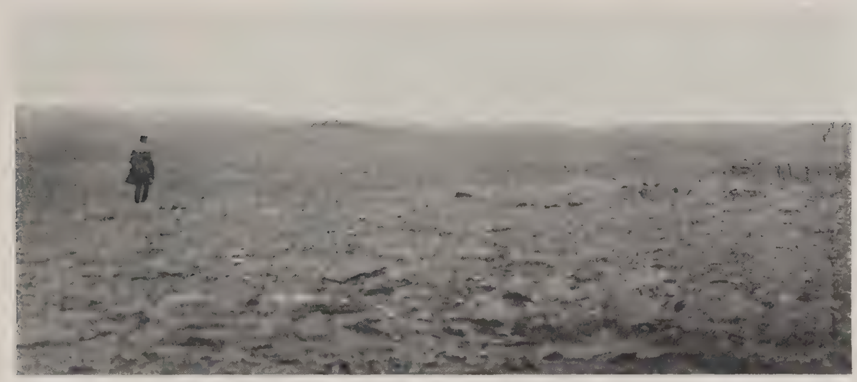
Plate XXIX.

Sketch map by O. Holtedahl of the country between Mashigin and Zivolka Fjords

Plate XXX.

Map showing the present ice cover of Novaya Zemlya. Gr.

Printed, September 15th 1924.



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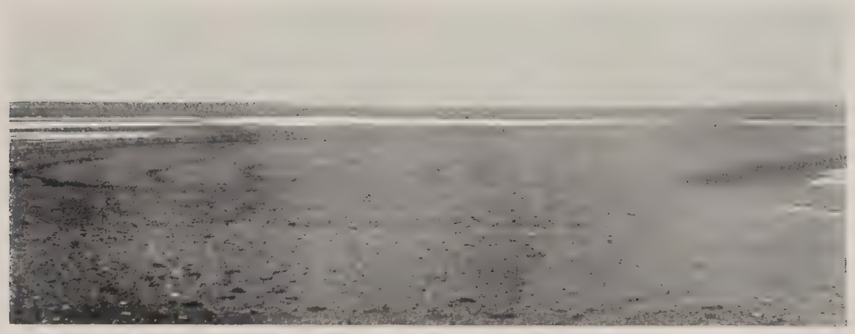

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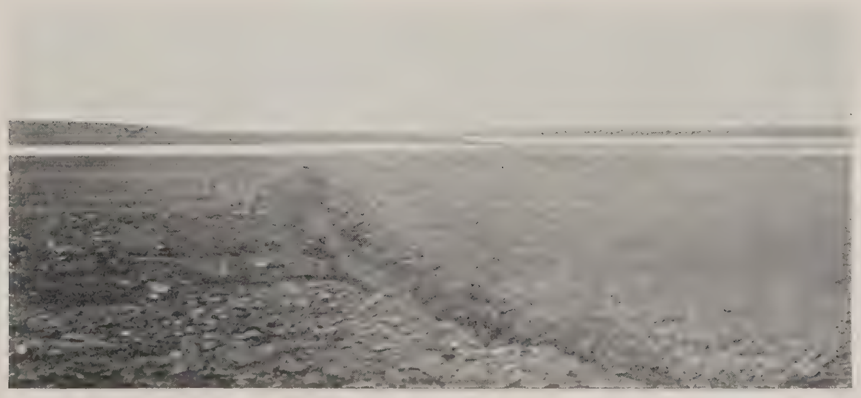

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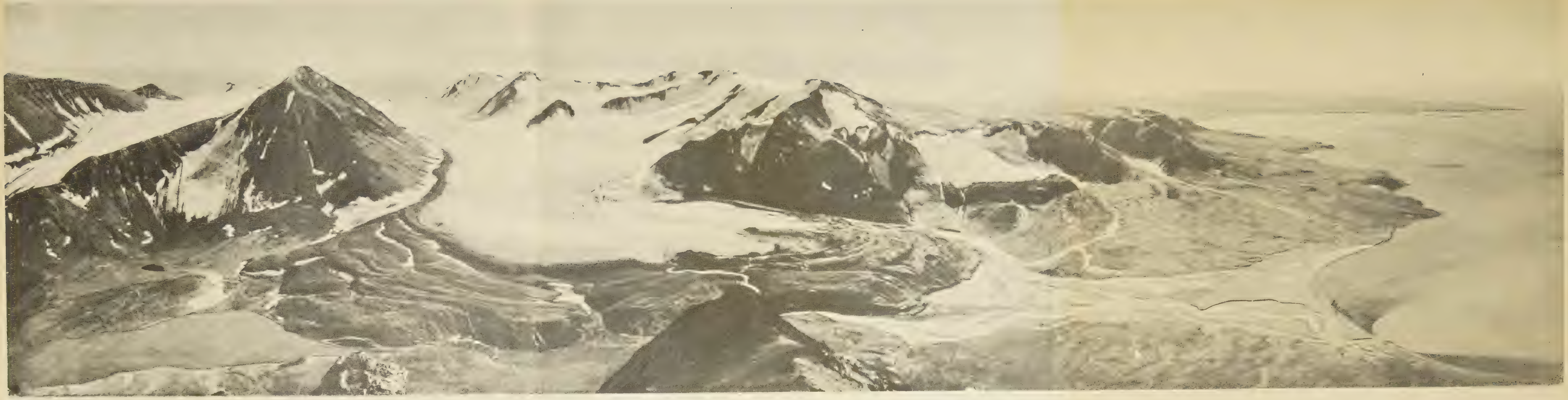

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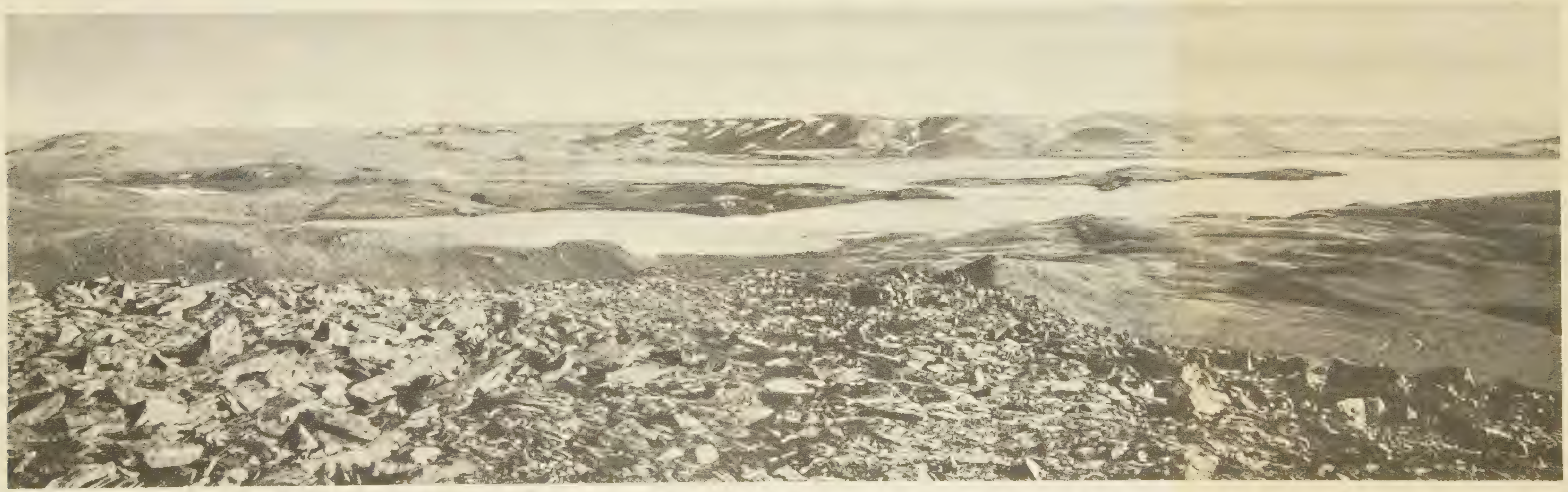

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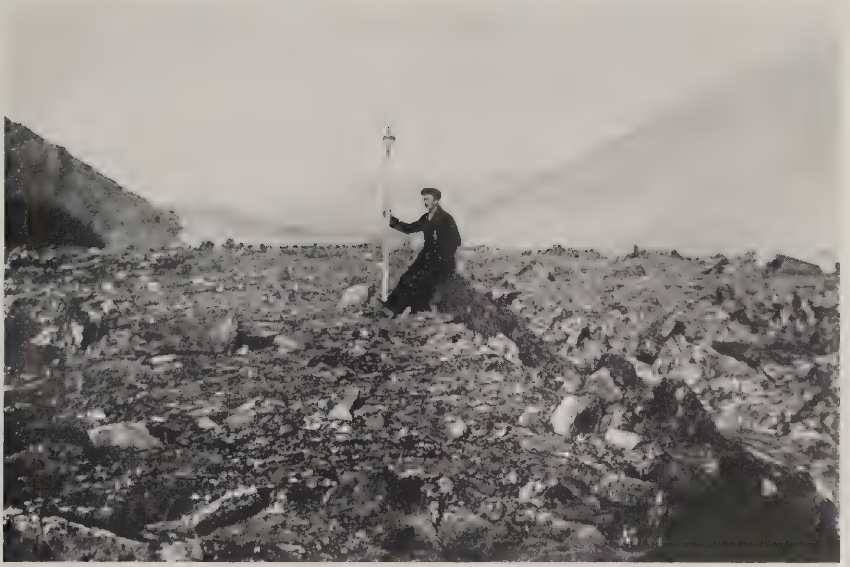

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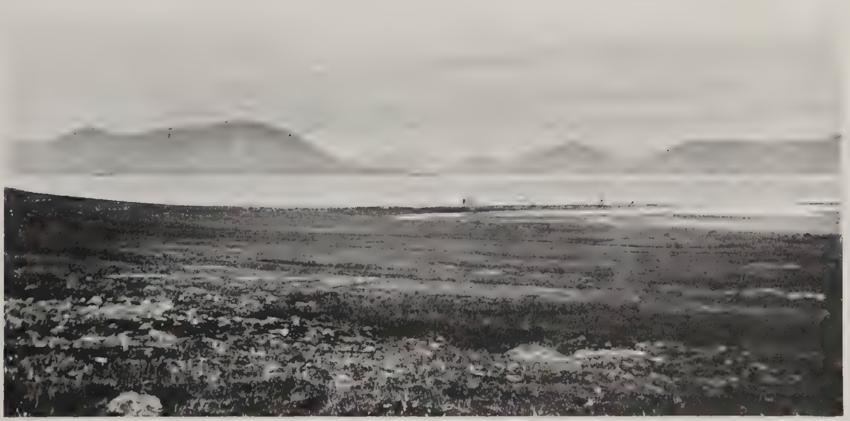

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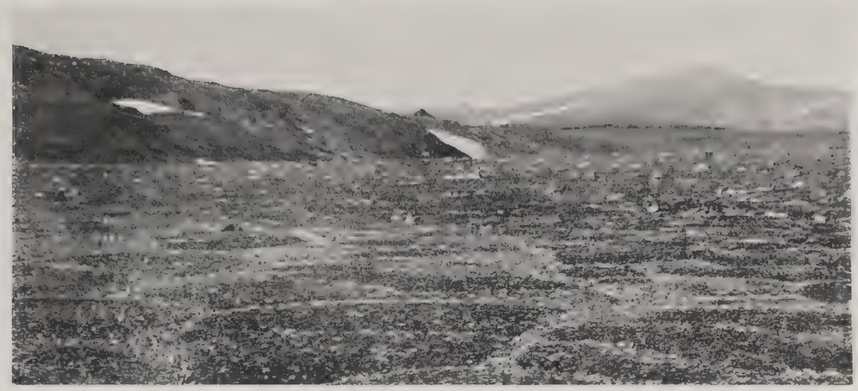

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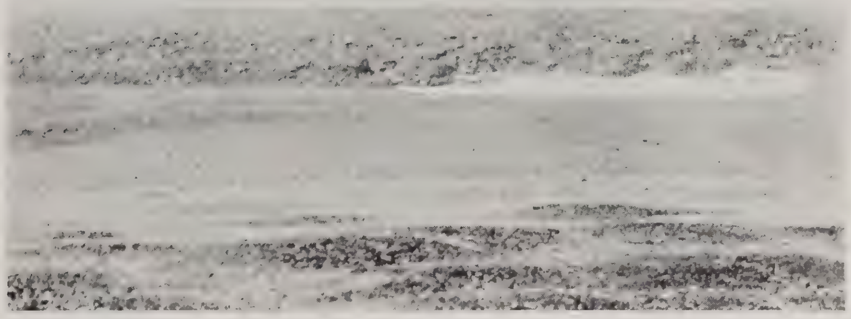

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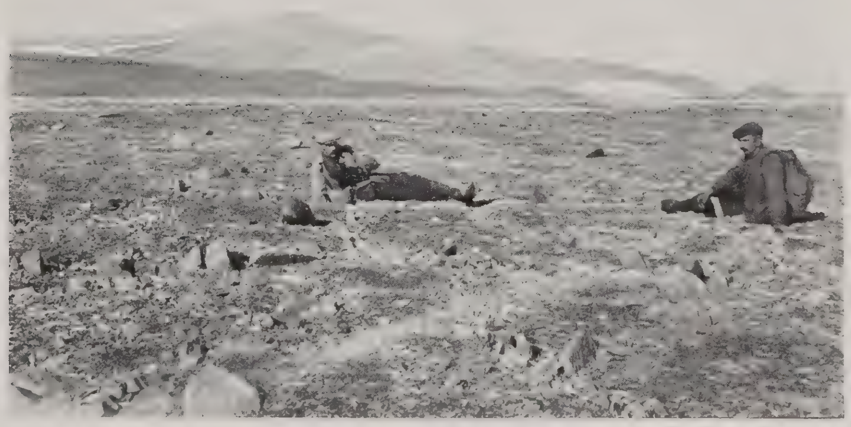

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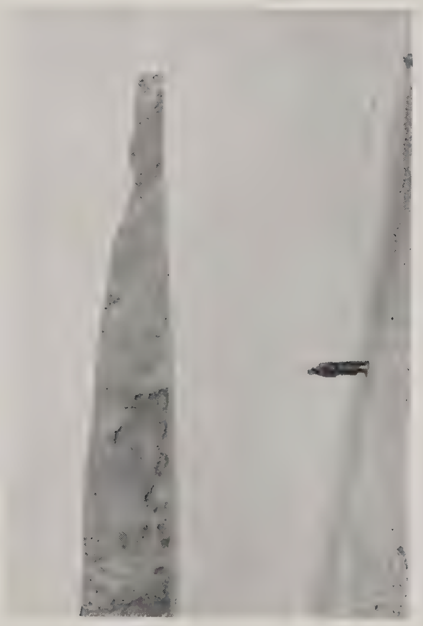

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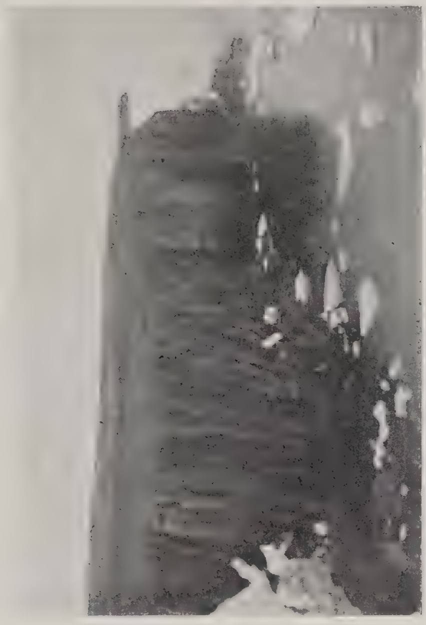

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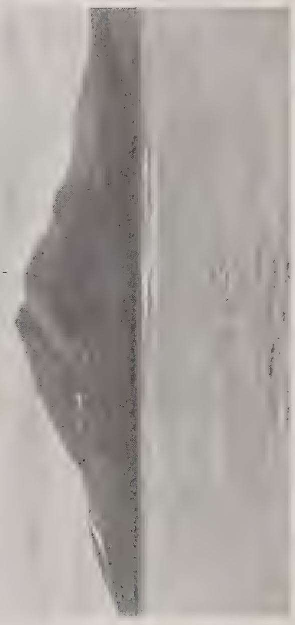

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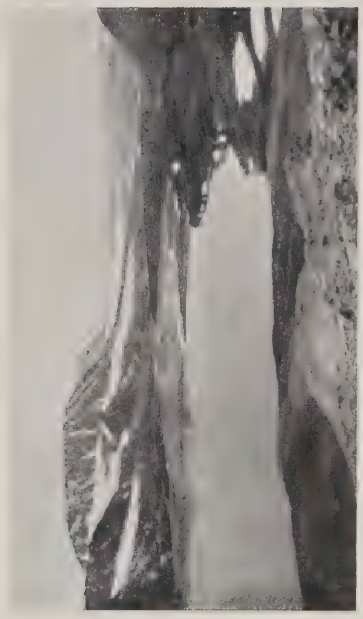

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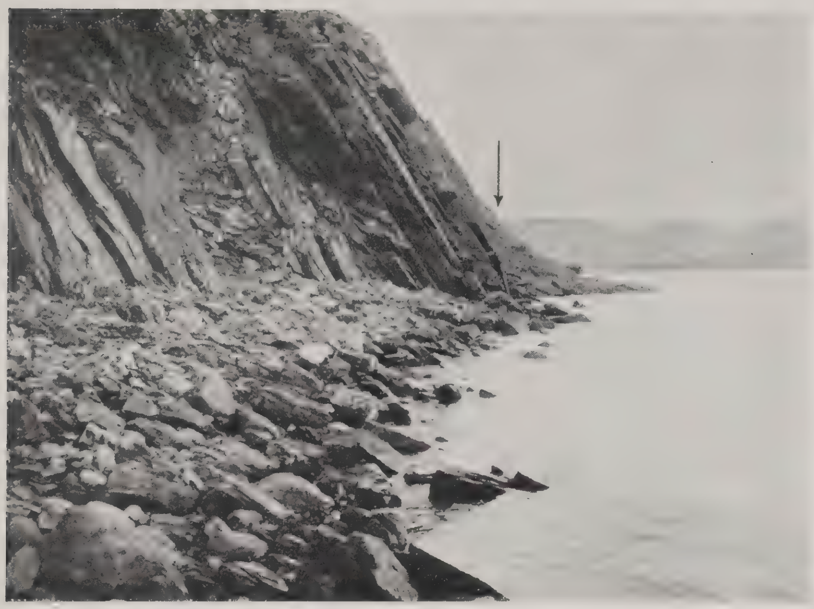

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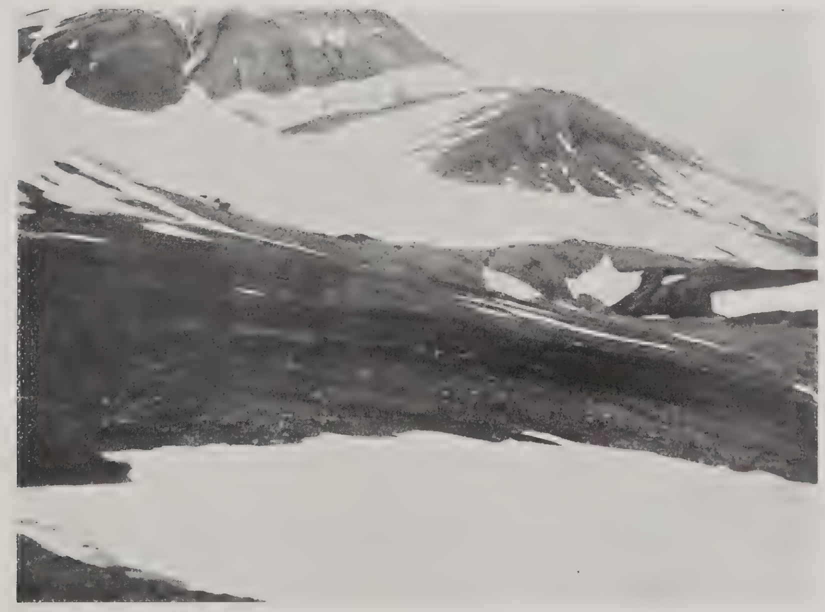

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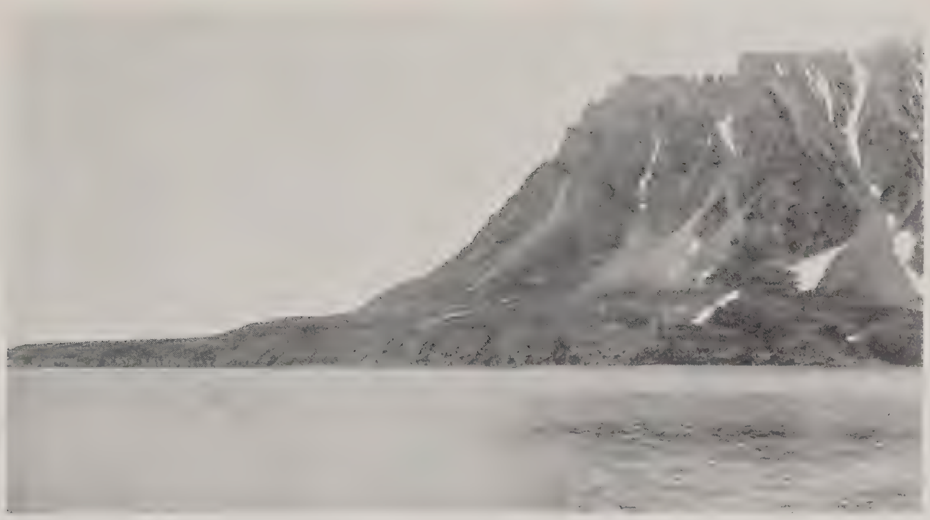

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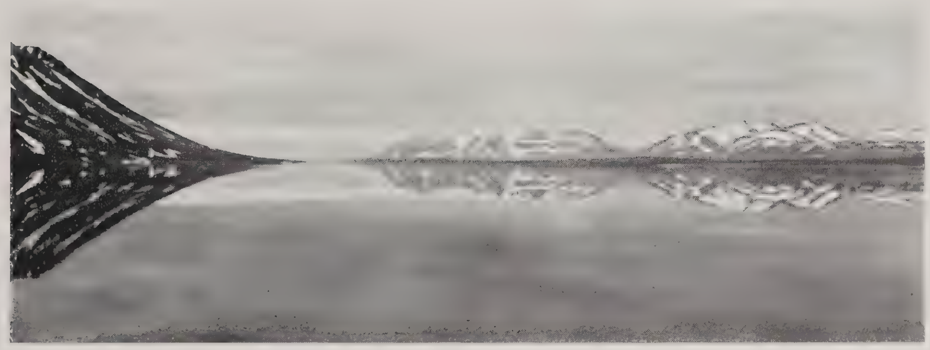

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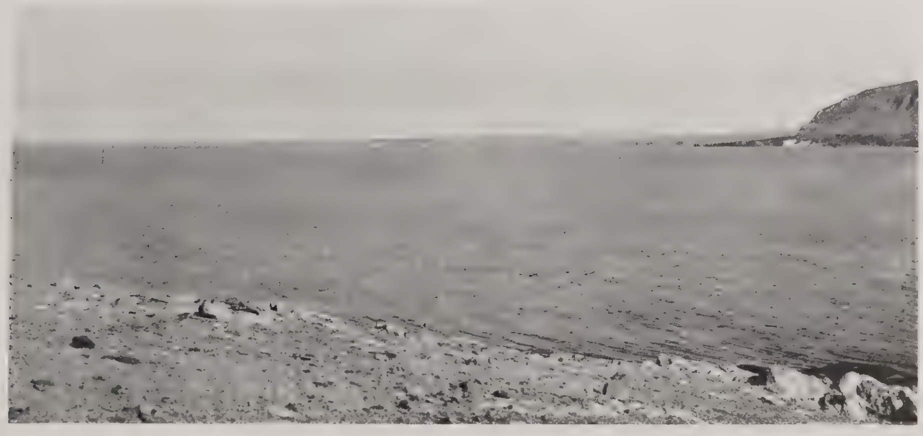

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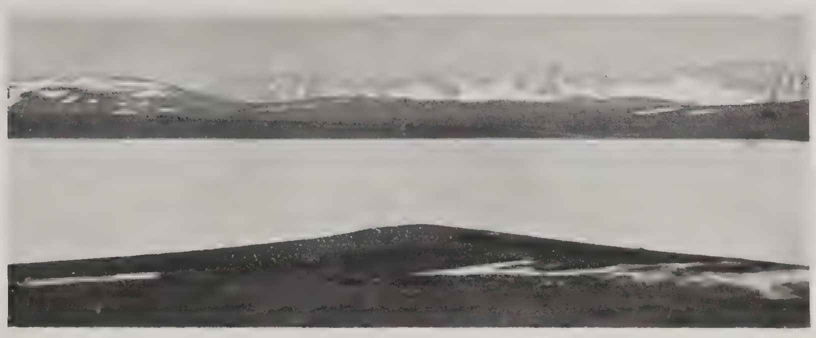

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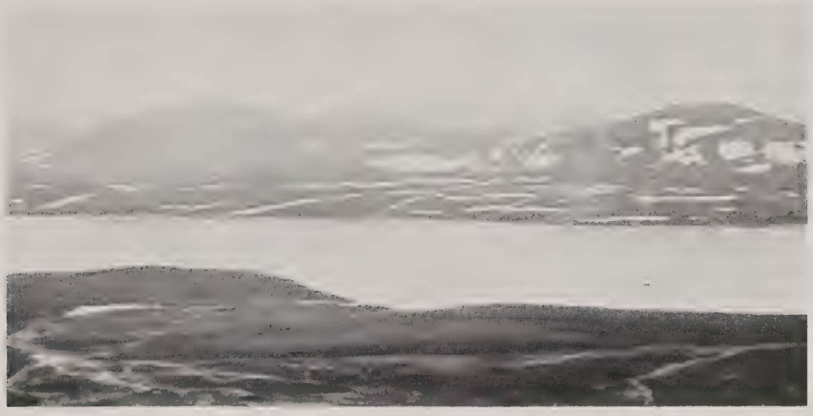
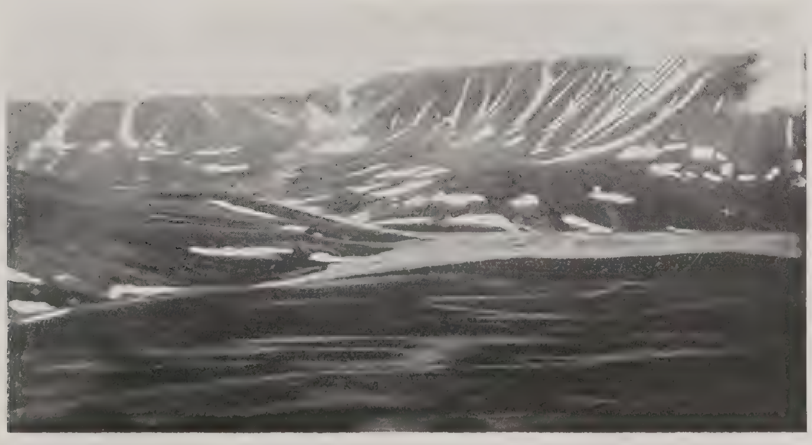


Fig. 2.



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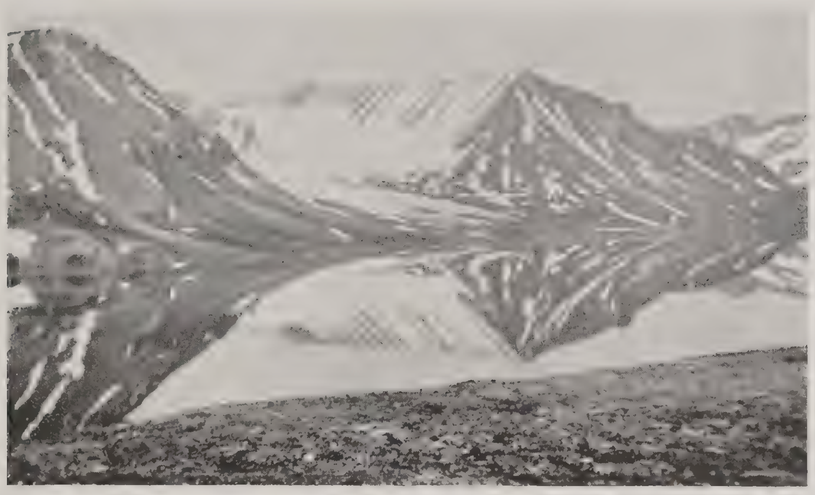


Fig. 1.

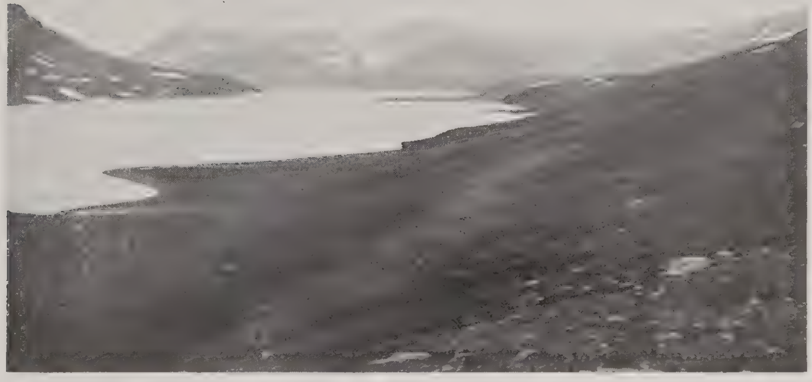


Fig. 2.

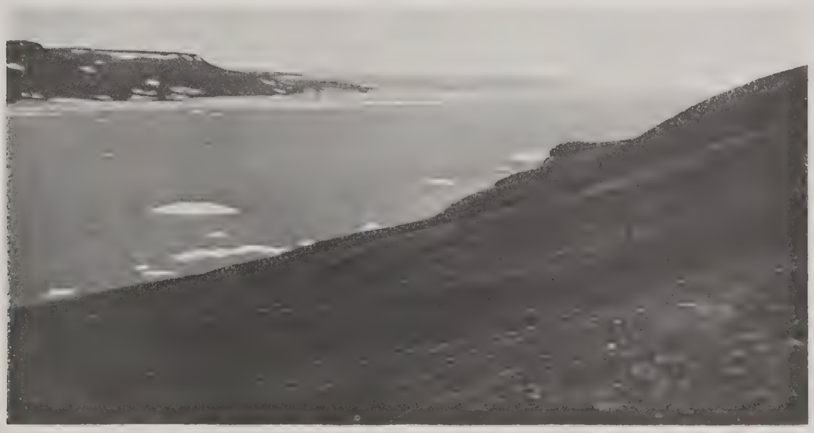


Fig. 3.

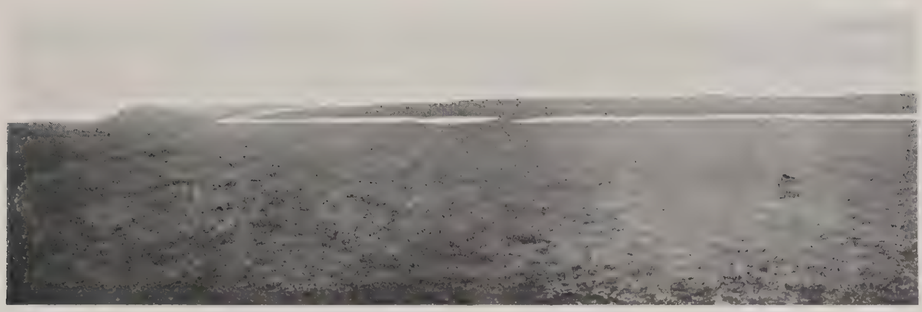


Fig. 1.

Fig. 2.

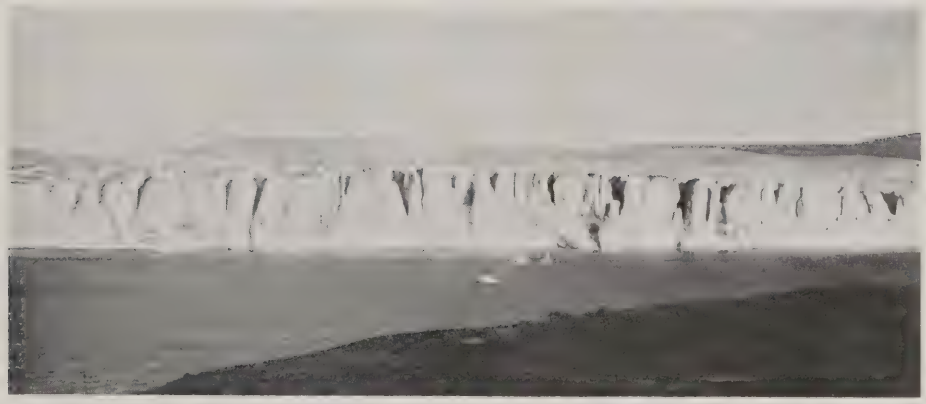


Fig. 3.

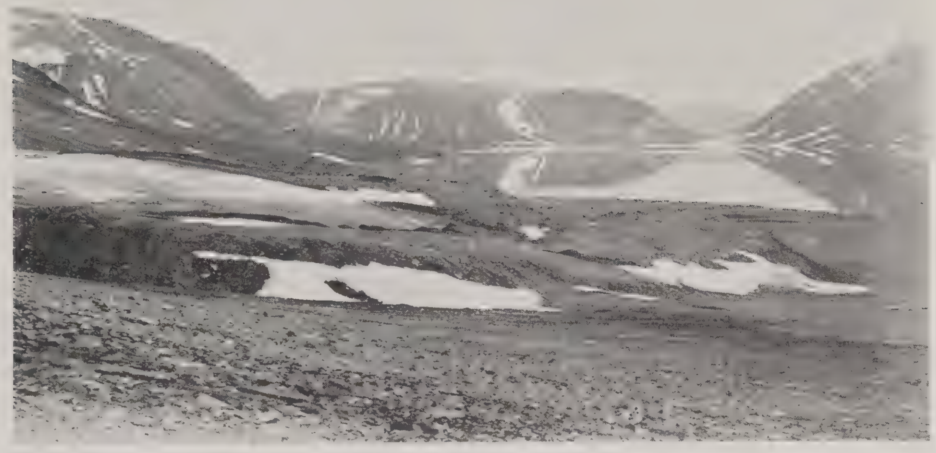


Fig. 1.

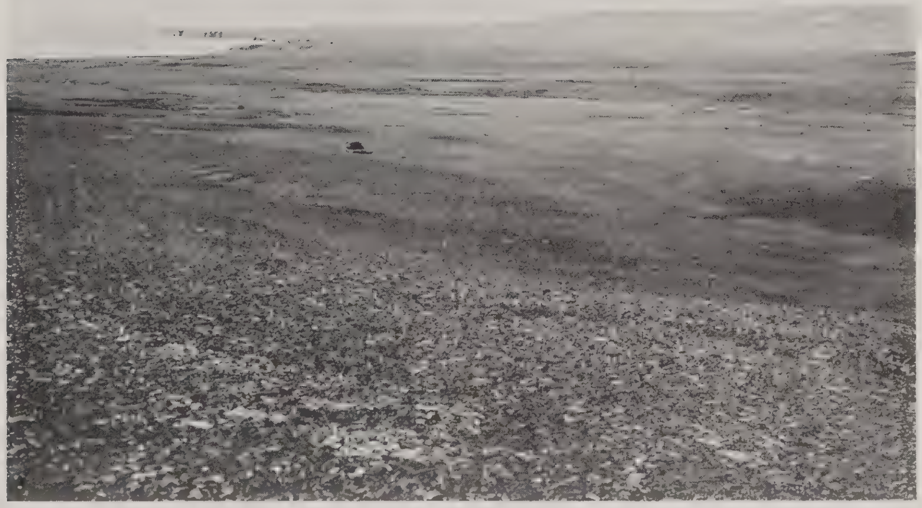


Fig. 2.

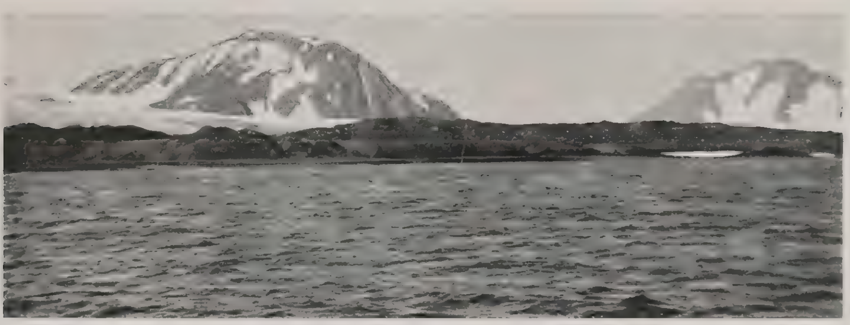


Fig. 1.

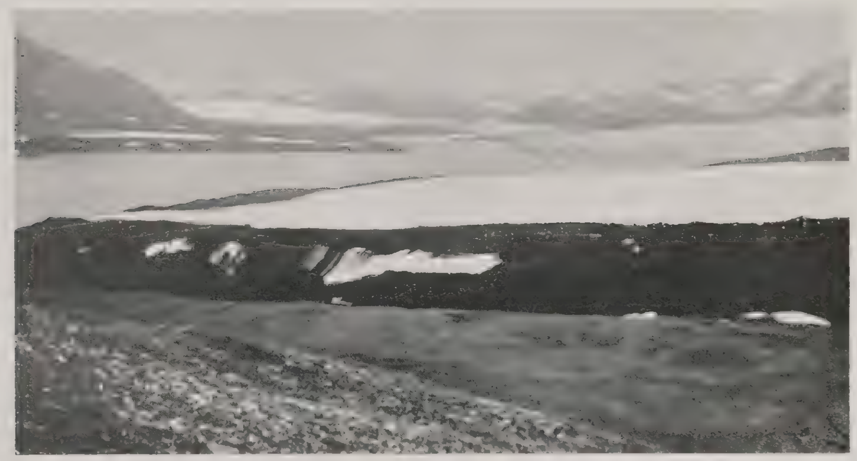


Fig. 2.

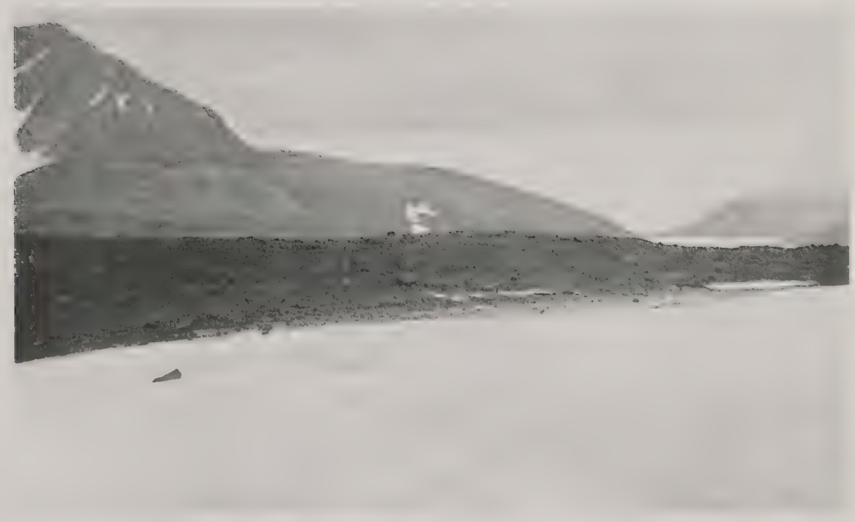


Fig. 3.

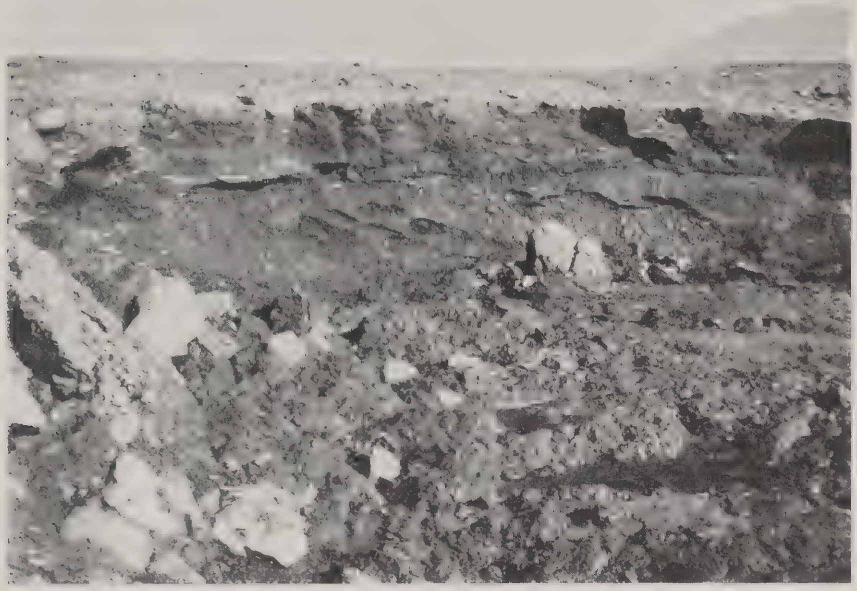
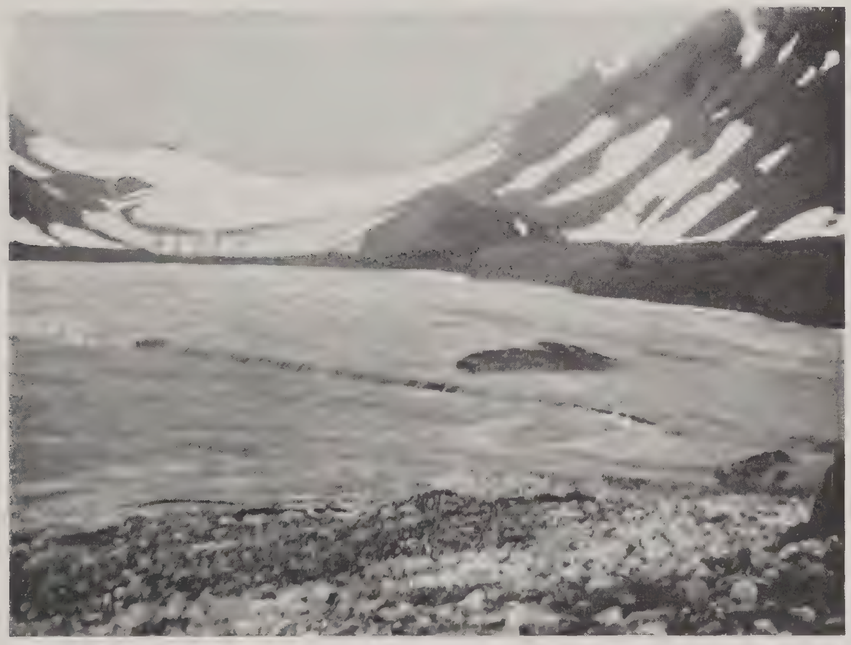


Fig. 1.



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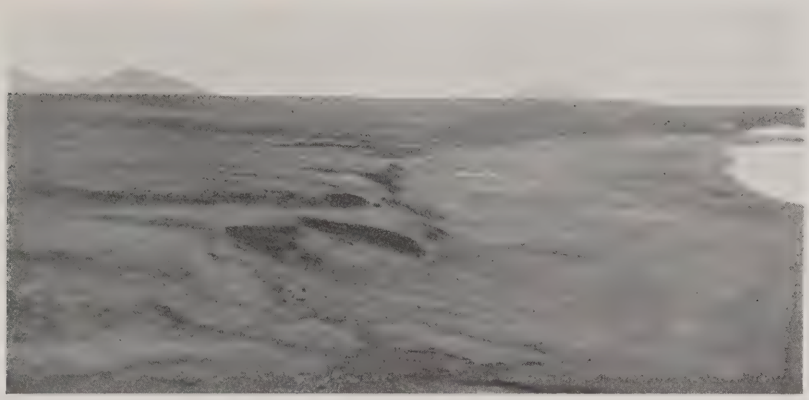
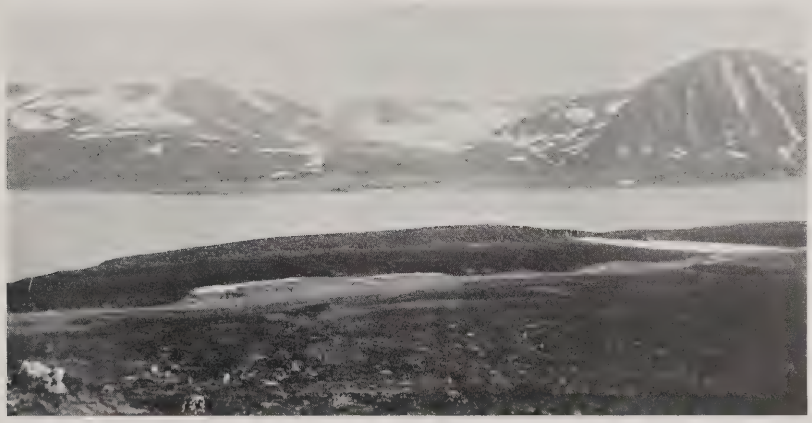


Fig. 1.



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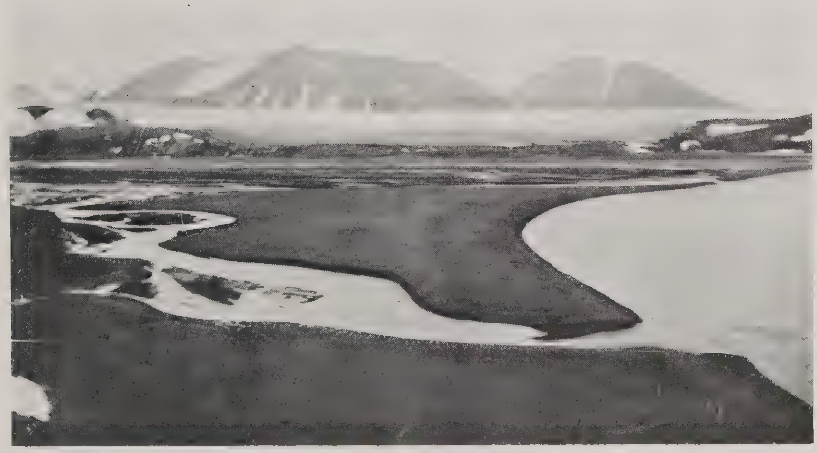


Fig. 3.

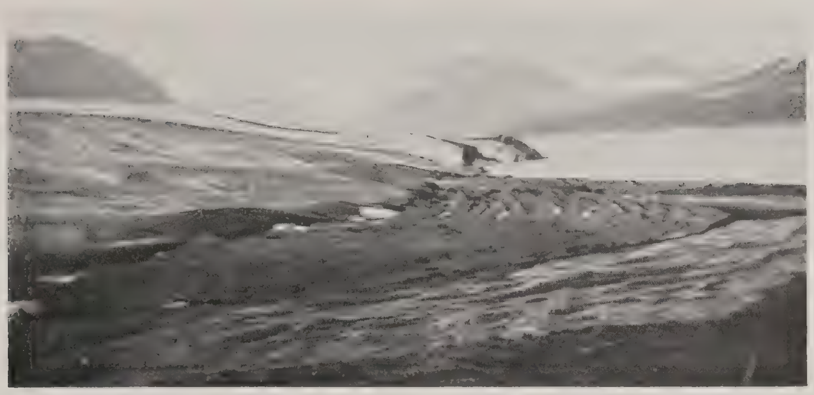


Fig. 1.

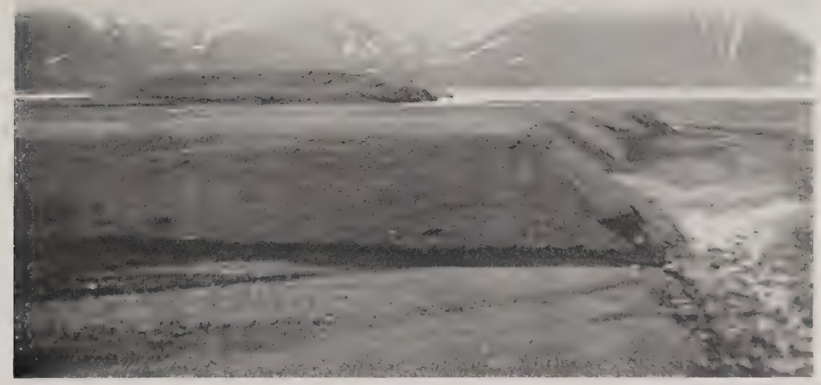


Fig. 2.

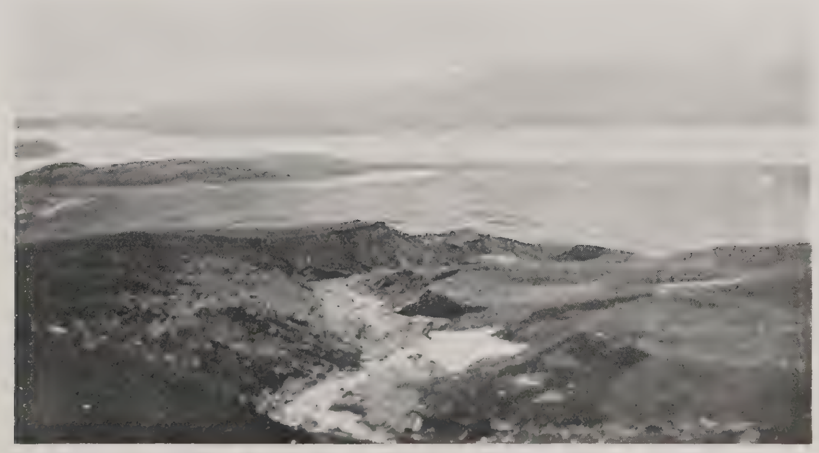


Fig. 3.

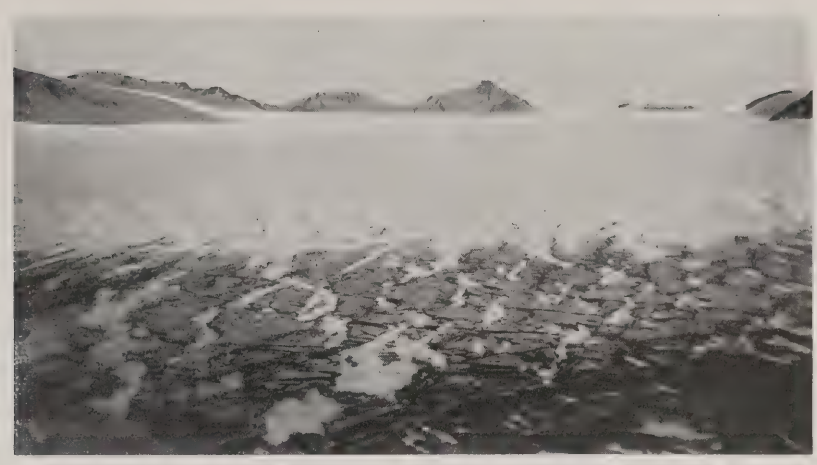


Fig. 1.

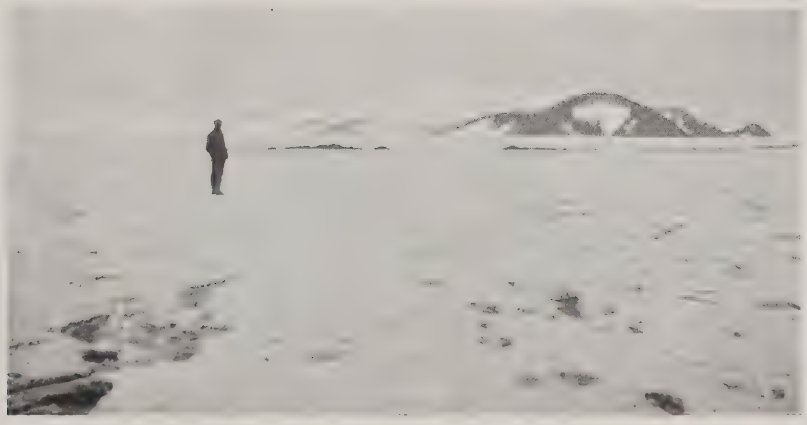


Fig. 2.

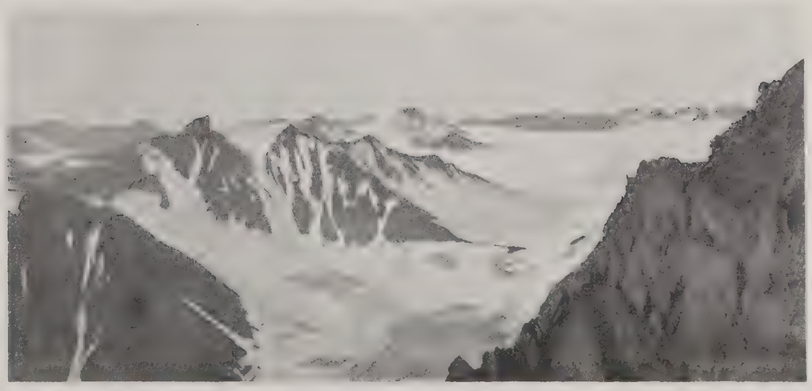
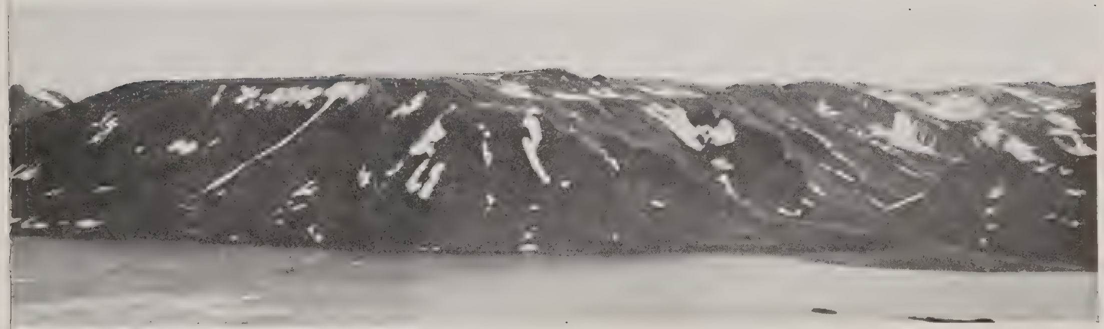


Fig. 3.

Pl. XVII.



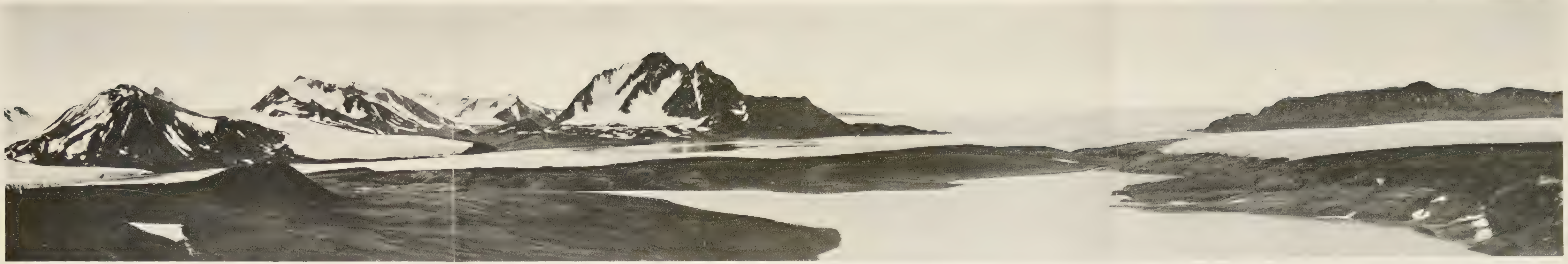


Fig. 1.

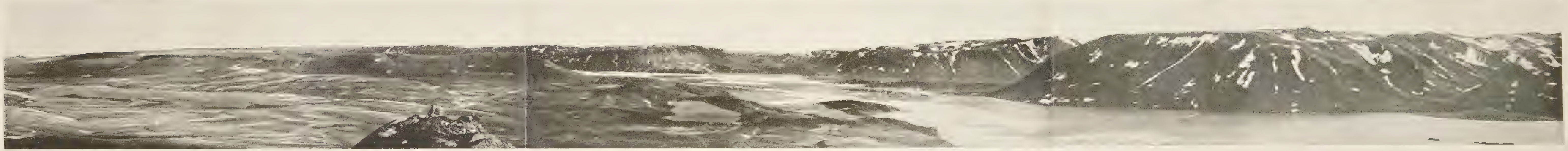


Fig. 2.

Fig. 3.

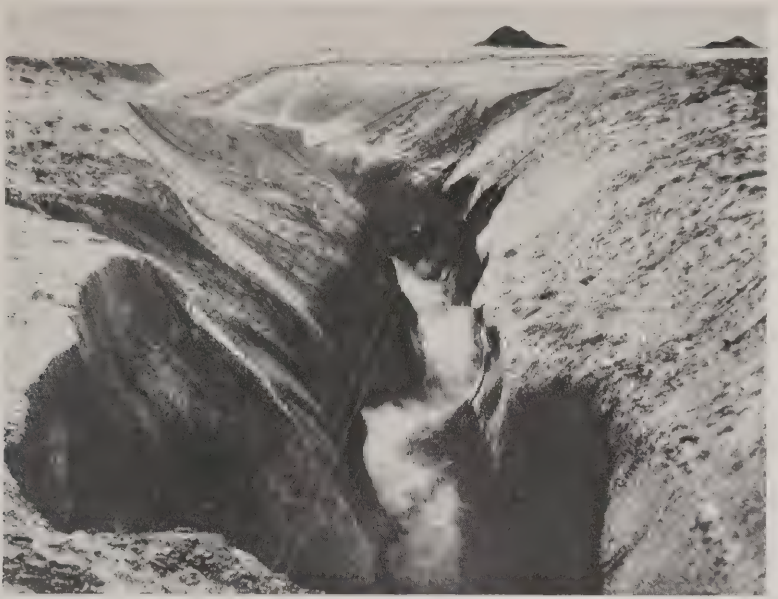


Fig. 1.

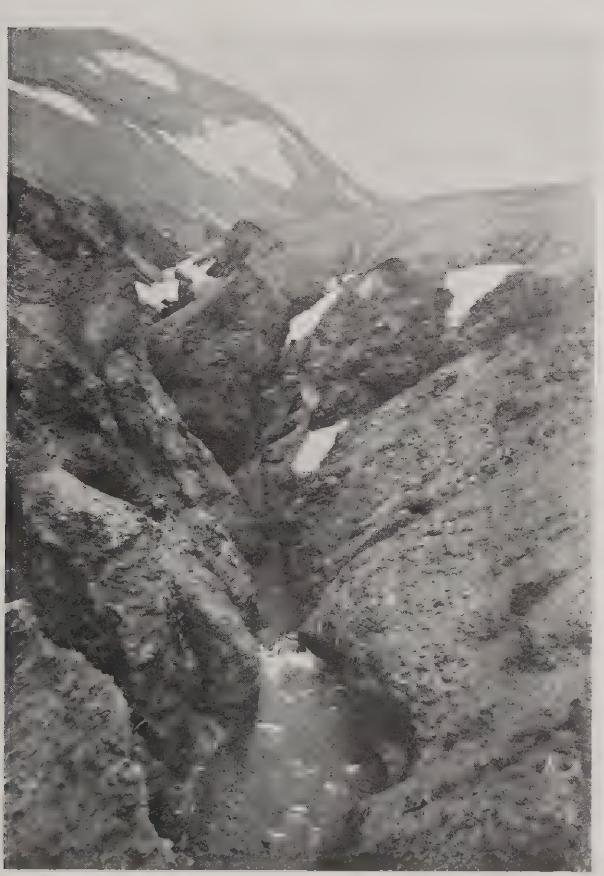


Fig. 2.

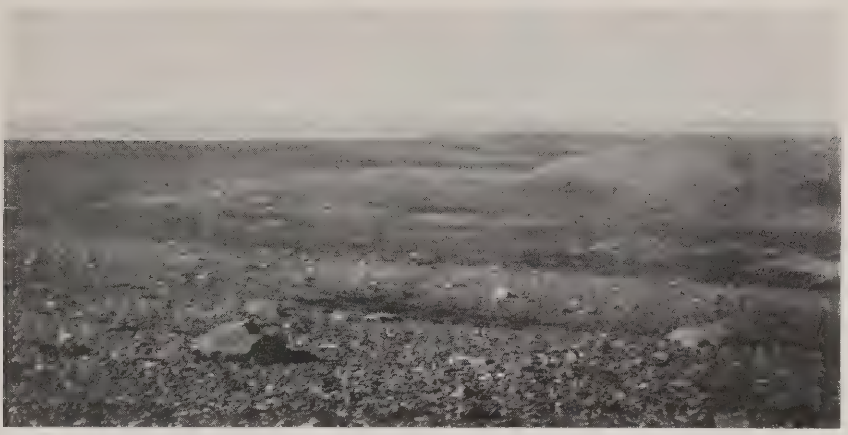
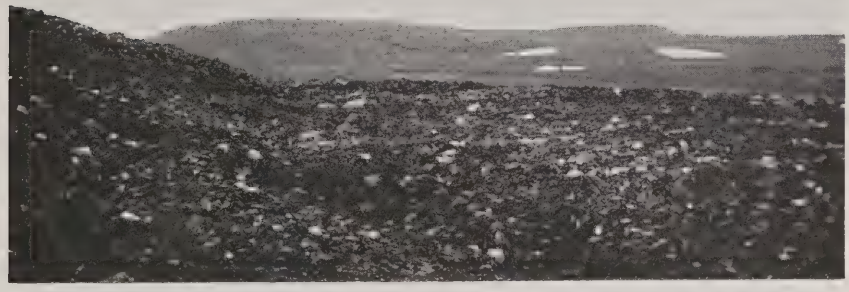


Fig. 1.



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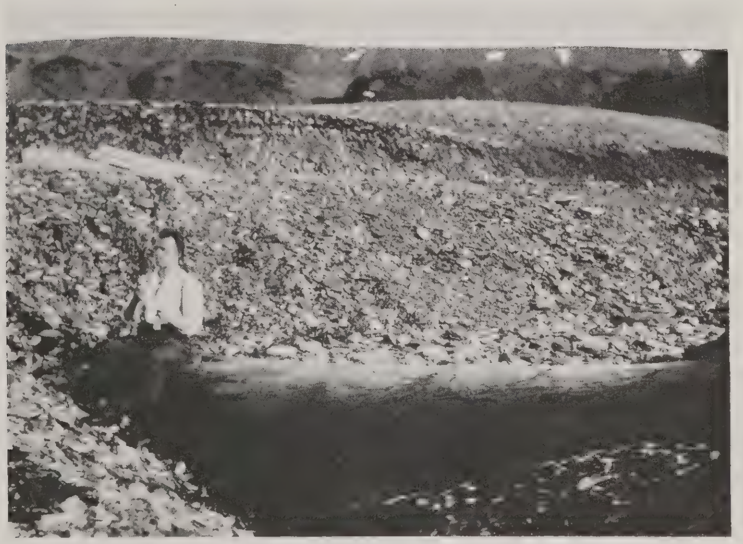

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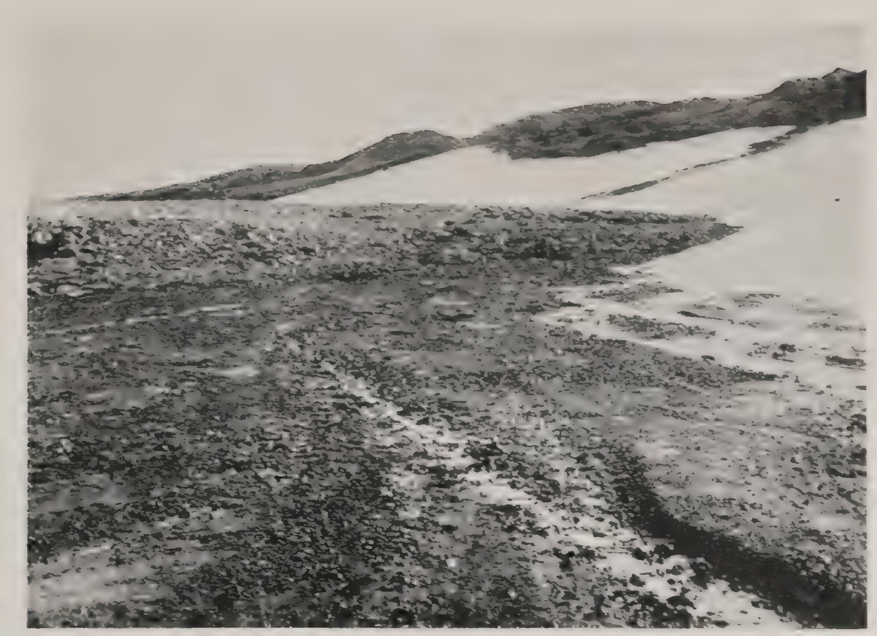
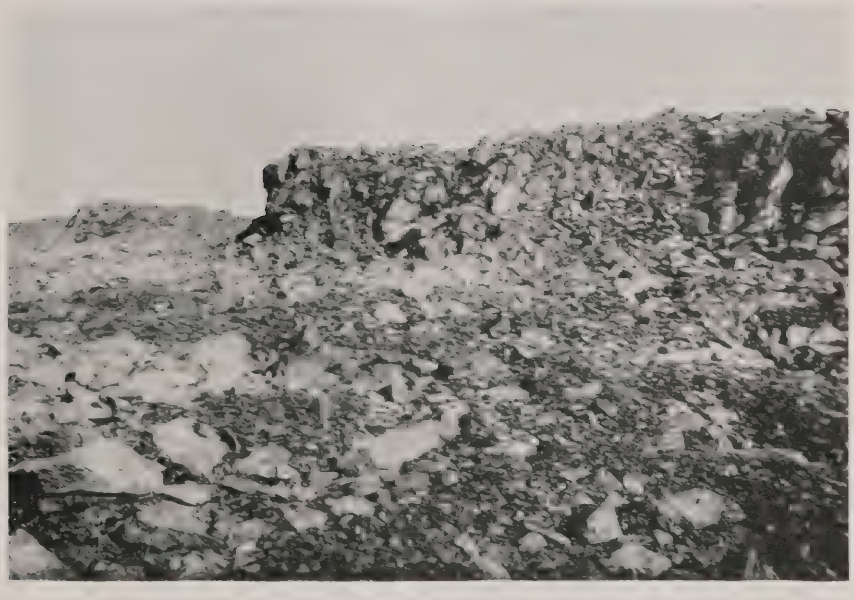


Fig. 1.



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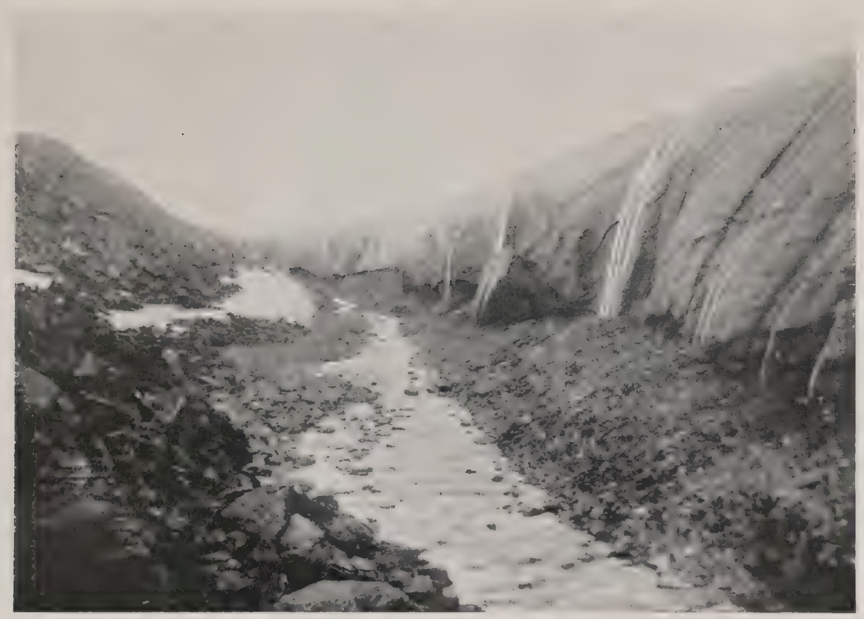
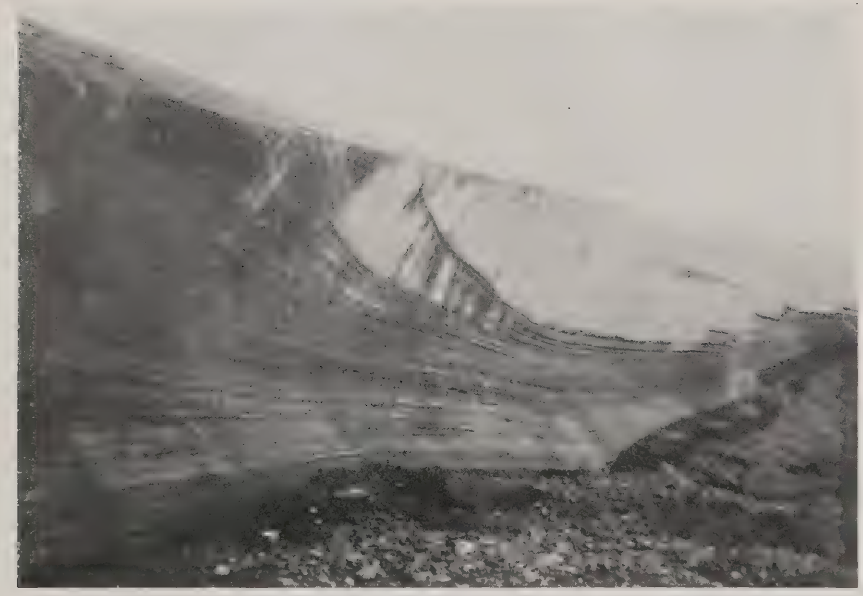


Fig. 1.



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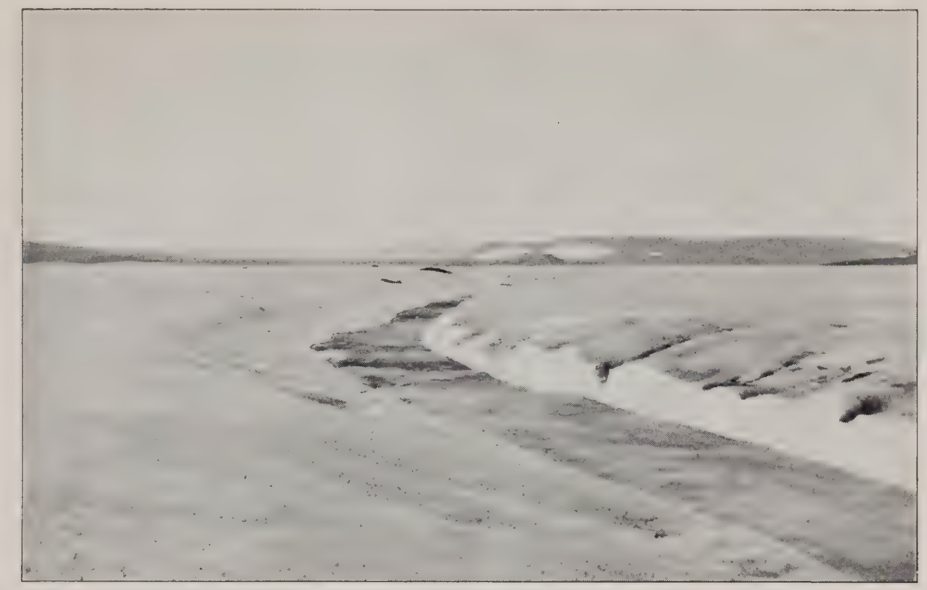

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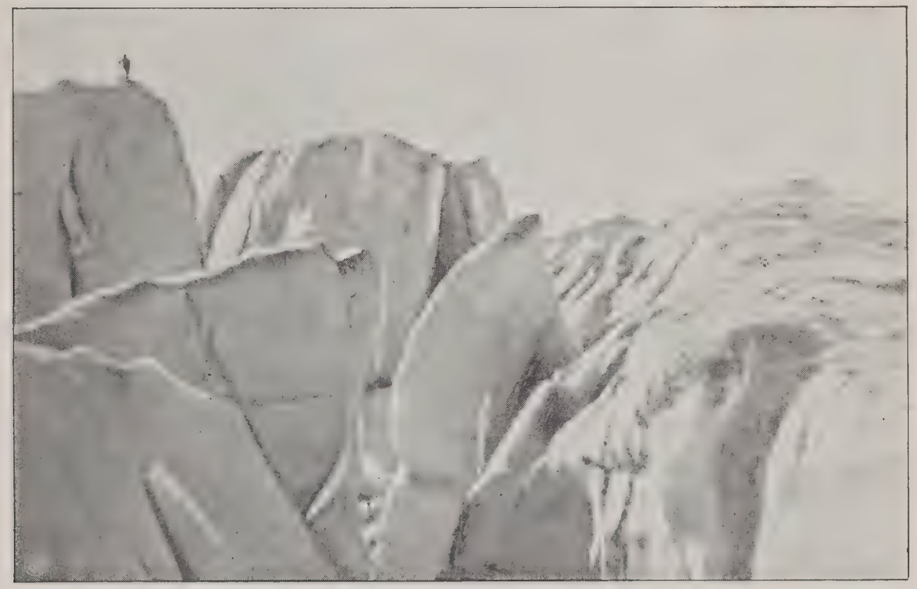

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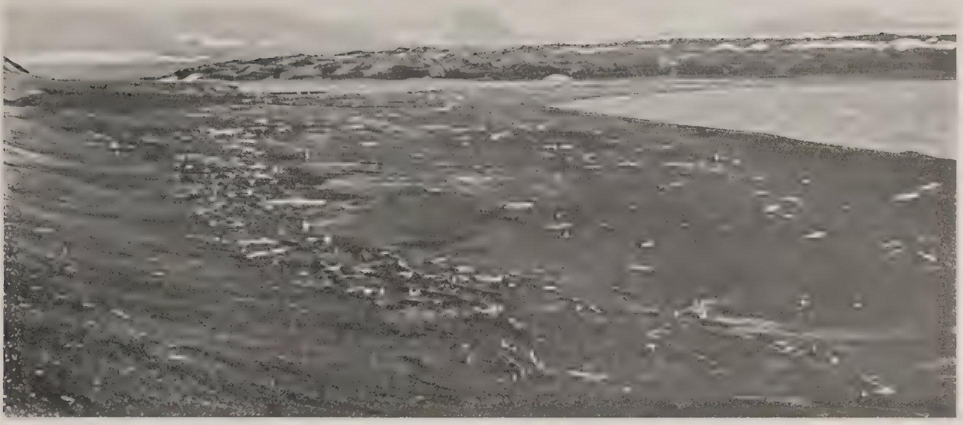
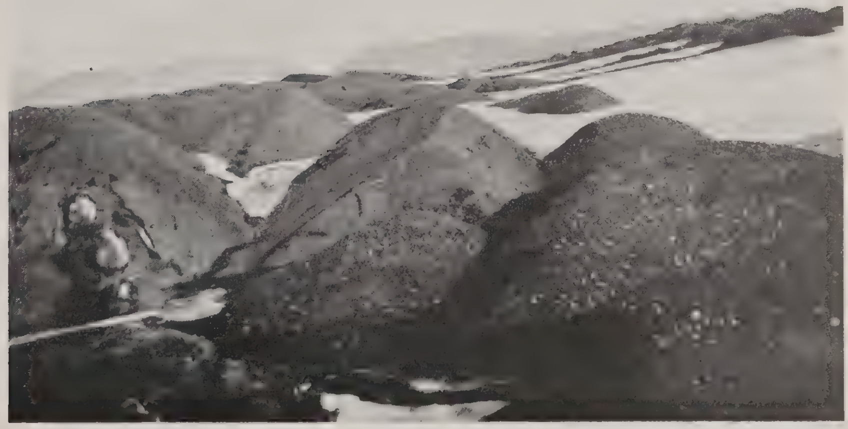


Fig. 1.



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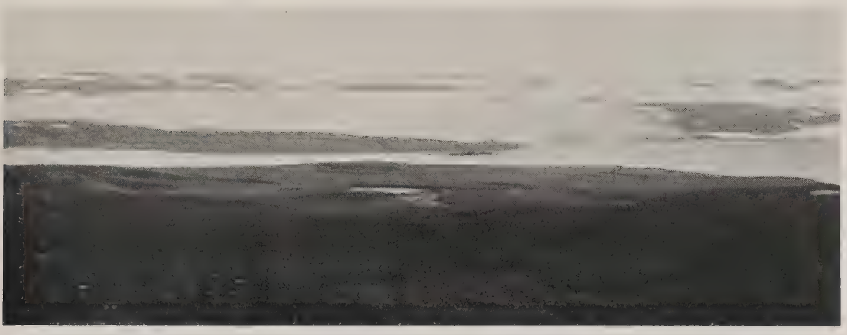


Fig. 1.

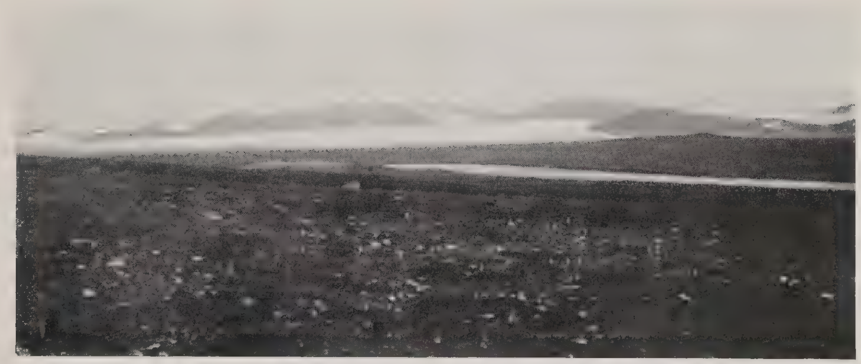


Fig. 2.

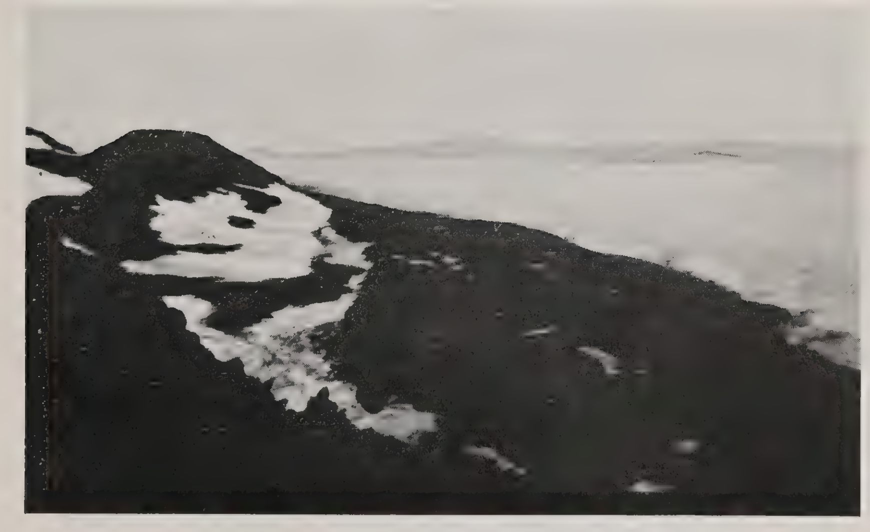


Fig. 3.

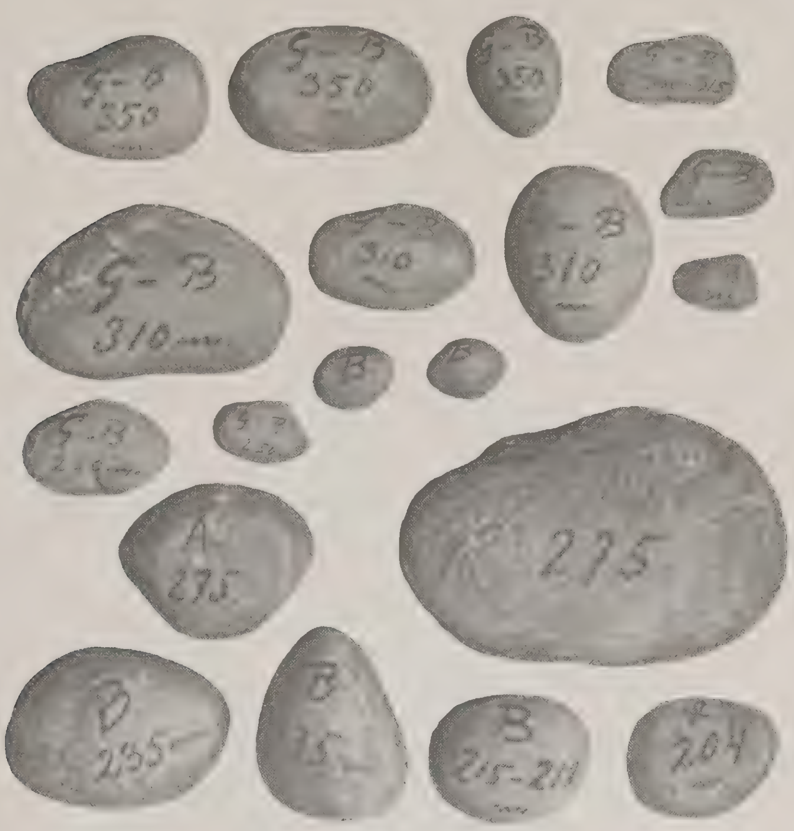

G-B
350
G-B
350
G-B
350
G-B
310
G-B
310
-B
310
B
B
G-B
A
275
K 275
B
235
B
75
B
215-211
204

Fig. 1.

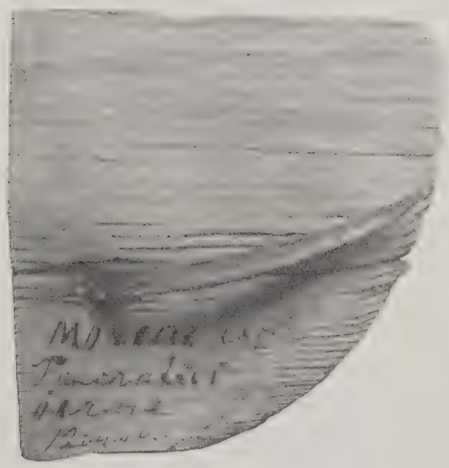
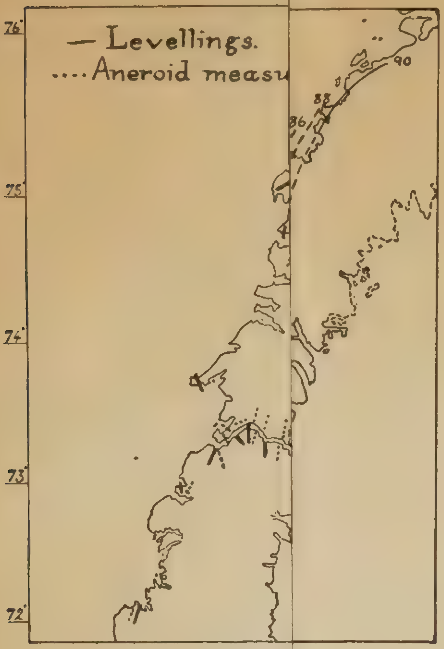
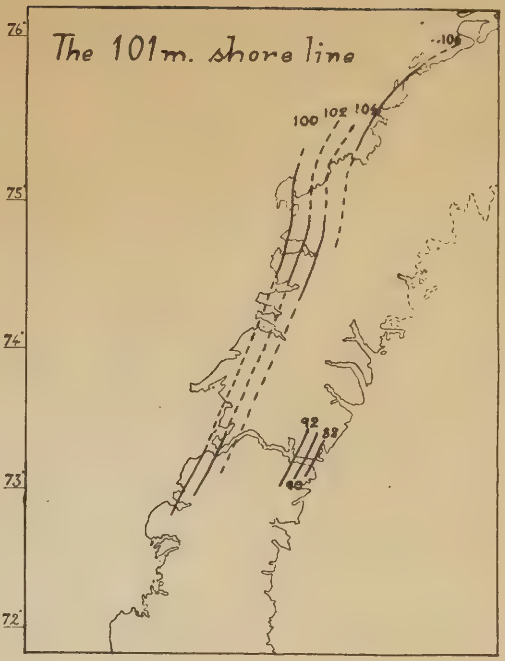
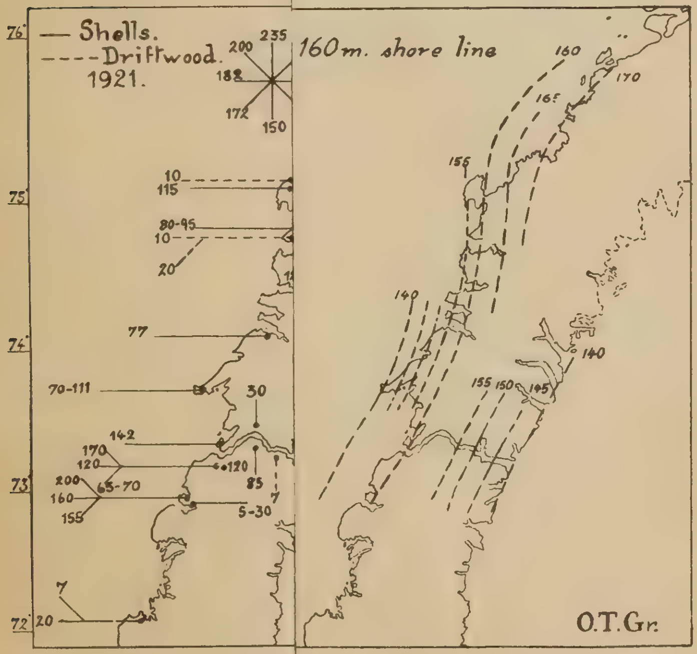
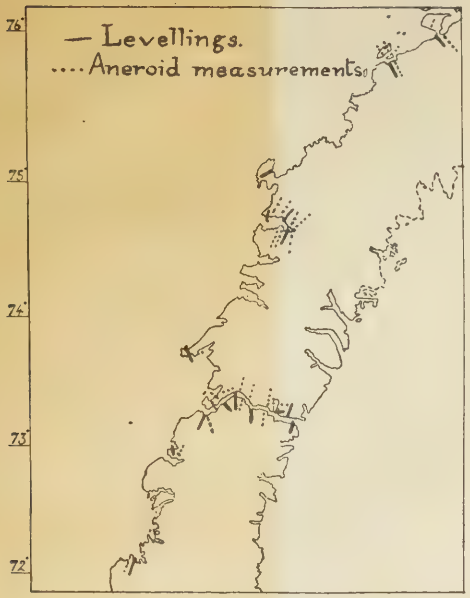


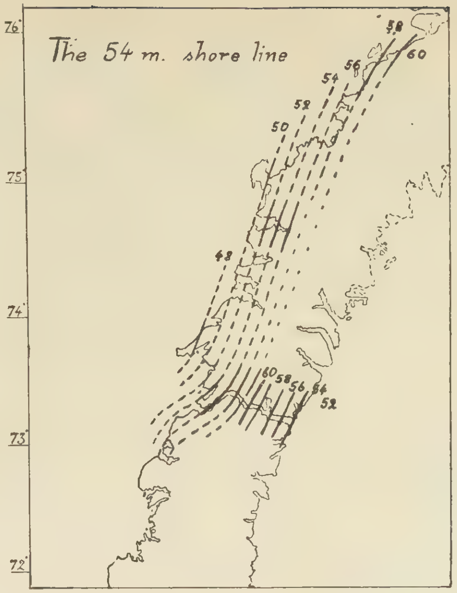
Fig. 2.

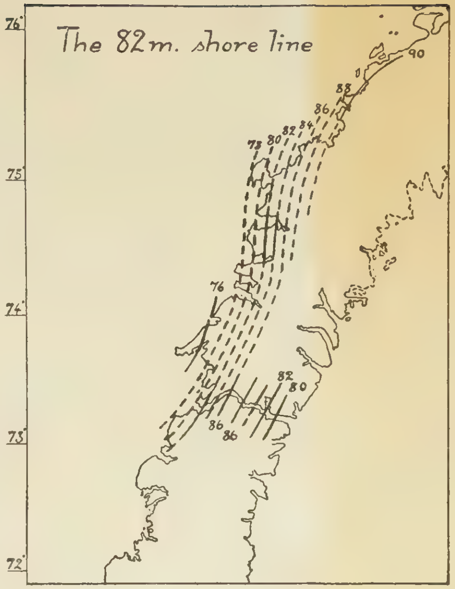

— Levellings.
.... Aneroid measu
76°
75°
74°
73°
72°
90
88
86

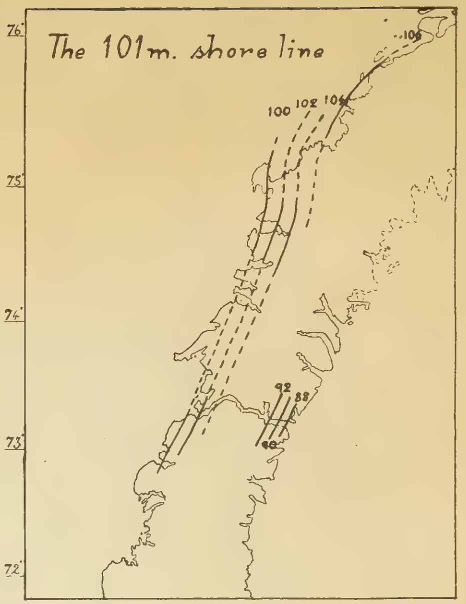

The 101m. shore line
76°
75°
74°
73°
72°
100
102
104
106
92
88

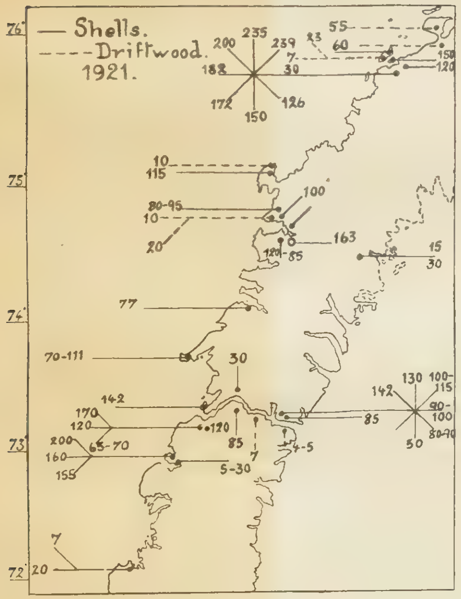

— Shells.
---- Driftwood.
1921.
160m. shore line
76°
75°
74°
73°
72°
200
235
182
172
150
10
115
80-95
10
20
77
70-111
30
142
170
120
120
85
7
200
65-70
160
155
5-30
7
20
160
165
170
156
140
140
155
150
145
O.T.Gr.


— Levellings.
···· Aneroid measurements.
76°
75°
74°
73°
72°


The 54 m. shore line
58
60
56
54
52
50
48
60
58
56
54
52
76°
75°
74°
73°
72°


The 82 m. shore line
90
88
86
84
82
80
78
76
82
80
86
86
76°
75°
74°
73°
72°


The 101 m. shore line
106
100
102
104
92
88
90
76°
75°
74°
73°
72°


— Shells.
---- Driftwood.
1921.
235
200
239
188
30
172
150
126
23
55
60
7
150
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10
115
100
80-95
10
20
163
120-85
15
30
77
70-111
30
142
170
120
•120
85
7
4-5
85
200
65-70
160
155
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130
100-115
90-100
80-70
50
7
20
76°
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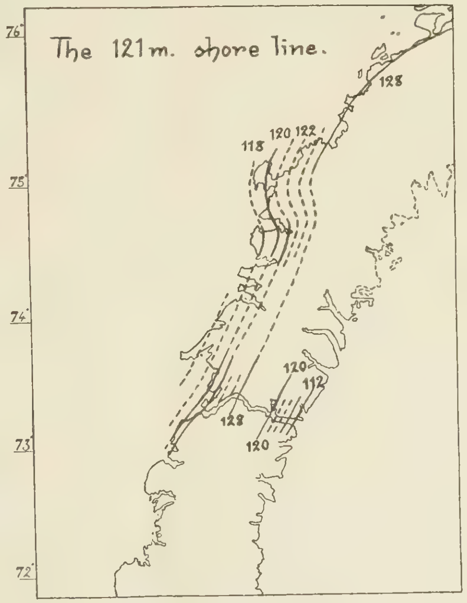
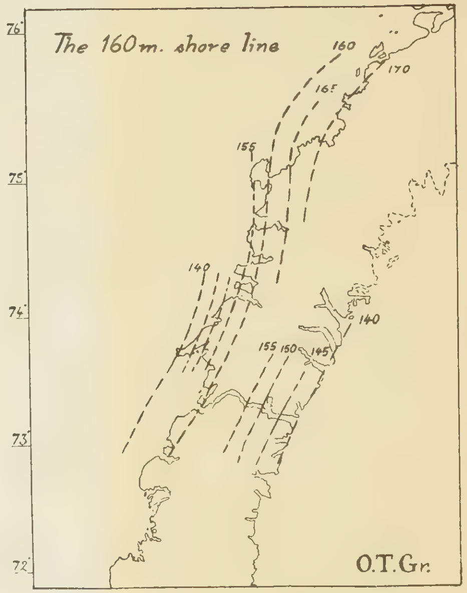
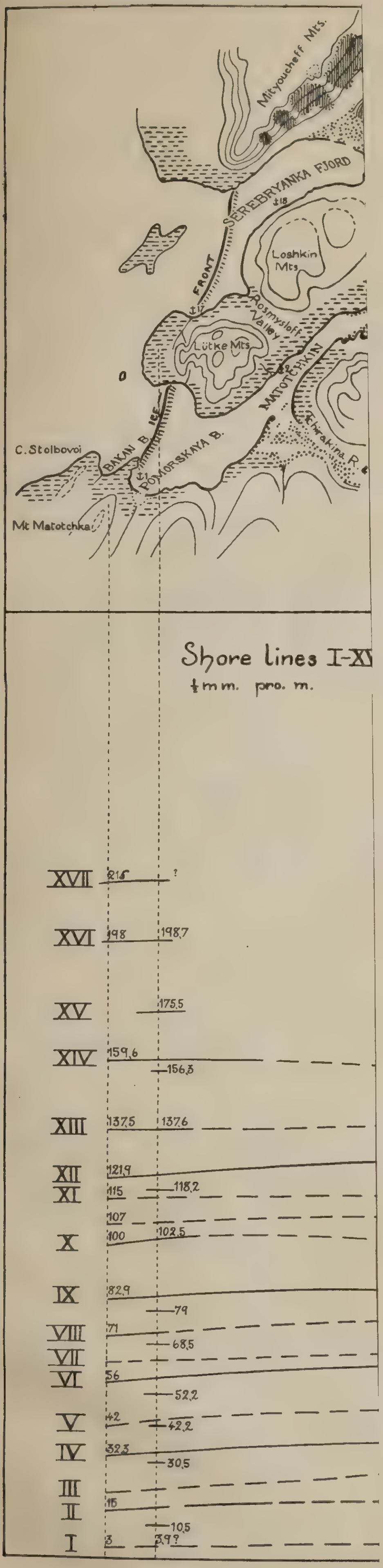
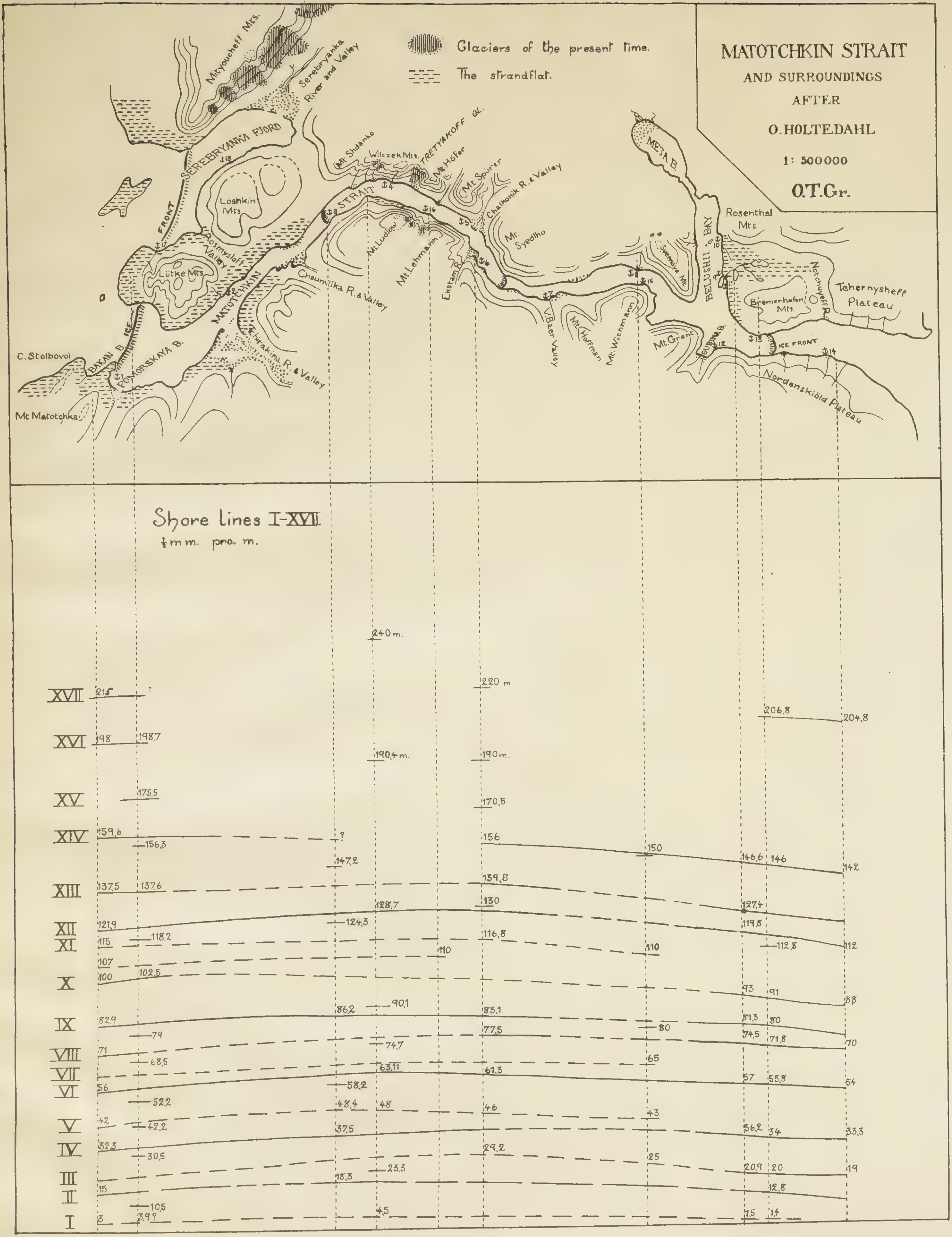
72°

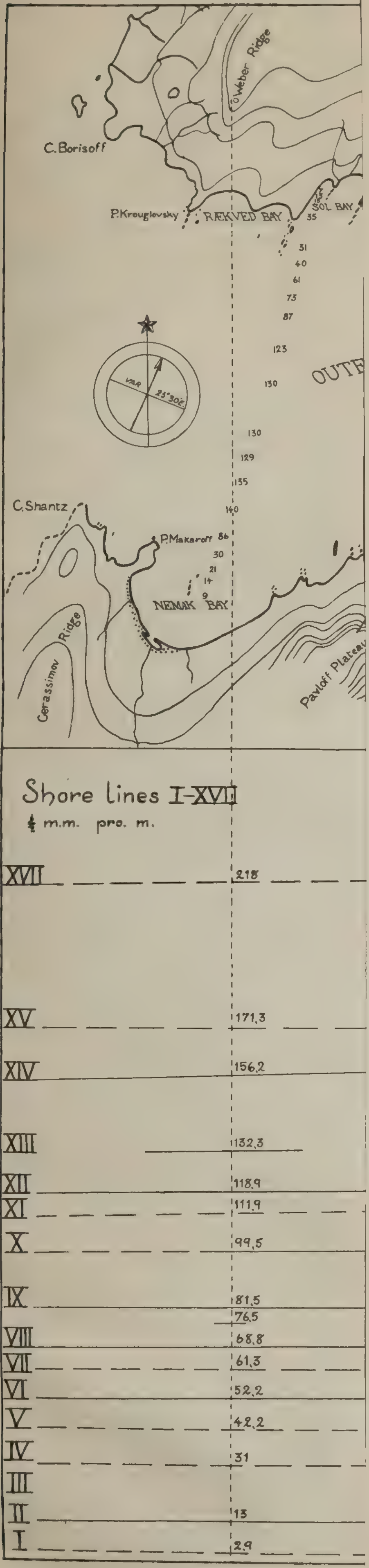

The 121 m. shore line.
128
118
120
122
120
112
128
120
76°
75°
74°
73°
72°

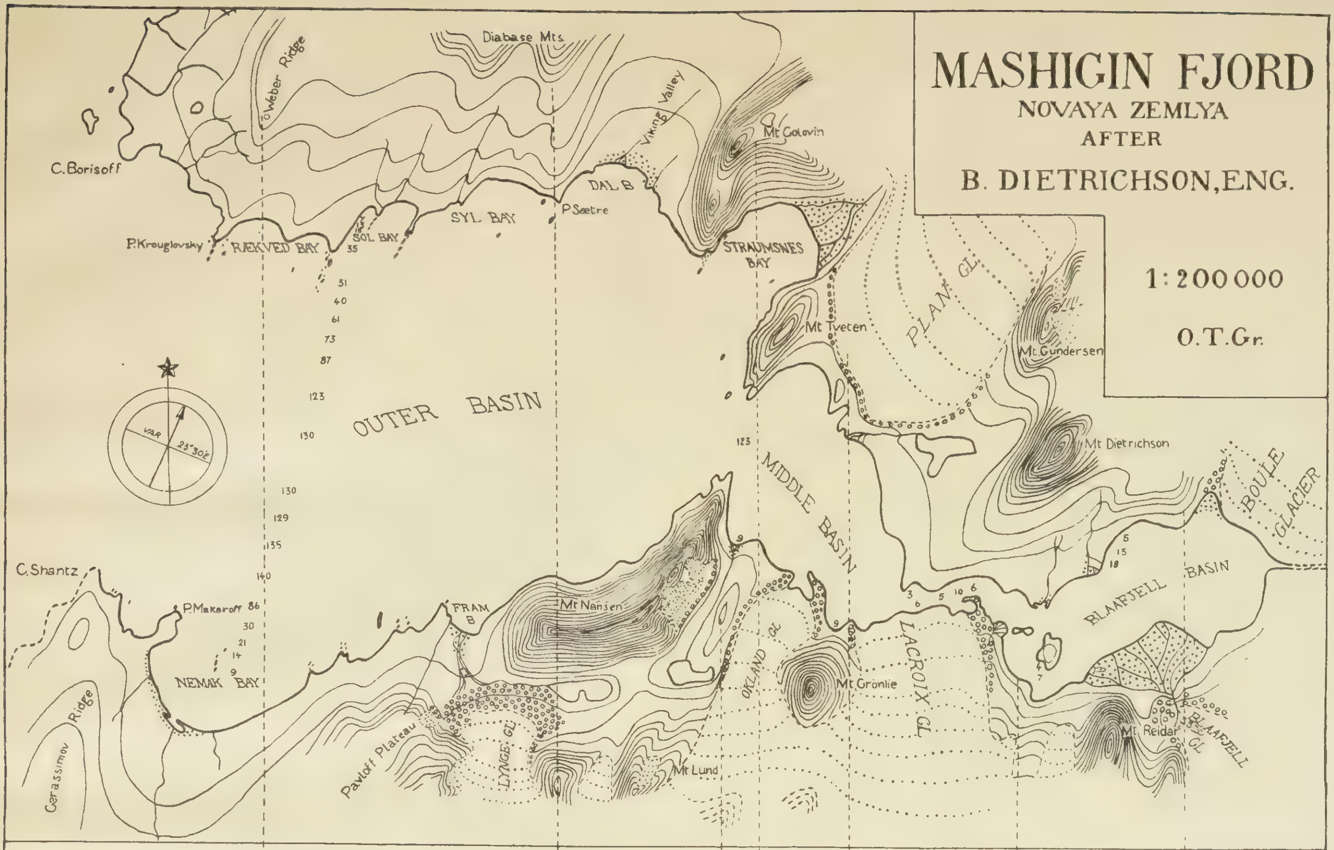

The 160 m. shore line
160
170
165
155
140
140
155
150
145
76°
75°
74°
73°
72°

O.T.Gr.


Mityoucheff Mts.
SEREBRYANKA FJORD
18
FRONT
17
Loshkin Mts
Rosmysloff Valley
Lütke Mts
MATOTCHKIN
2
Khrakina R.
C. Stolbovoi
BAKAN B.
ICE
POMORSKAYA B.
1
Mt Matotchka
Shore lines I-X
1mm. pro. m.
XVII
215
?
XVI
198
198,7
XV
175,5
XIV
159,6
156,3
XIII
137,5
137,6
XII
121,9
XI
115
118,2
107
X
100
102,5
IX
82,9
79
VIII
71
68,5
VII
VI
56
52,2
V
42
42,2
IV
32,3
30,5
III
II
15
10,5
I
3
3,9?


MATOTCHKIN STRAIT
AND SURROUNDINGS
AFTER
O. HOLTEDAHL
1: 500000
O.T.Gr.
Glaciers of the present time.
The strandflat.
Mityoucheff Mts.
Serebryanka River and Valley
SEREBRYANKA FJORD
FRONT
Loshkin Mts.
Mt Shdanko
Wilczek Mts.
TRETYAKOFF GL.
Mt Höfer
Mt Spörer
Chalhonik R. & Valley
STRAIT
Rosmysloff Valley
Lütke Mts
MATOTCHKIN
Chaumilika R. & Valley
Mt Ludlow
Mt Lehmann
Ekstam R.
Mt Syedlho
META B.
BELUSHII B. BAY
Rosenthal Mts.
Syemaya Mt.
Notchuyeff R.
Tchernysheff Plateau
Bremerhafen Mts.
ICE FRONT
Nordenskiöld Plateau
Mt Grant
GUBINA B.
Mt Wichmann
Mt Hoffman
V. Baer Valley
Ehrakina R. & Valley
POMORSKAYA B.
BAKAN B.
ICE
C. Stolbovoi
Mt Matotchka
Shore lines I-XVII
1 mm. pro. m.
240 m.
220 m
XVII 215 ?
206.8 204.8
XVI 198 198.7
190.4 m.
190 m.
XV 175.5
170.5
XIV 159.6 156.3 ? 147.2 156 150 146.6 146 142
XIII 137.5 137.6 139.8 127.4
128.7 130
XII 121.9 124.3 119.8
XI 115 118.2 116.8 110 110 112.8 112
107
X 100 102.5 93 91 88
86.2 90.1 85.1
IX 82.9 79 80 81.3 80 70
77.5 74.7 74.5 71.8
VIII 71 68.5 65
63.11 61.3
VII VI 56 58.2 57 55.8 54
52.2
V 42 42.2 48.4 48 46 43
37.5 36.2 34 33.3
IV 32.3 30.5 29.2 25 20.9 20 19
III 18.3 23.3
II 15 10.5 12.8
I 3 3.9? 4.5 1.5 1.4

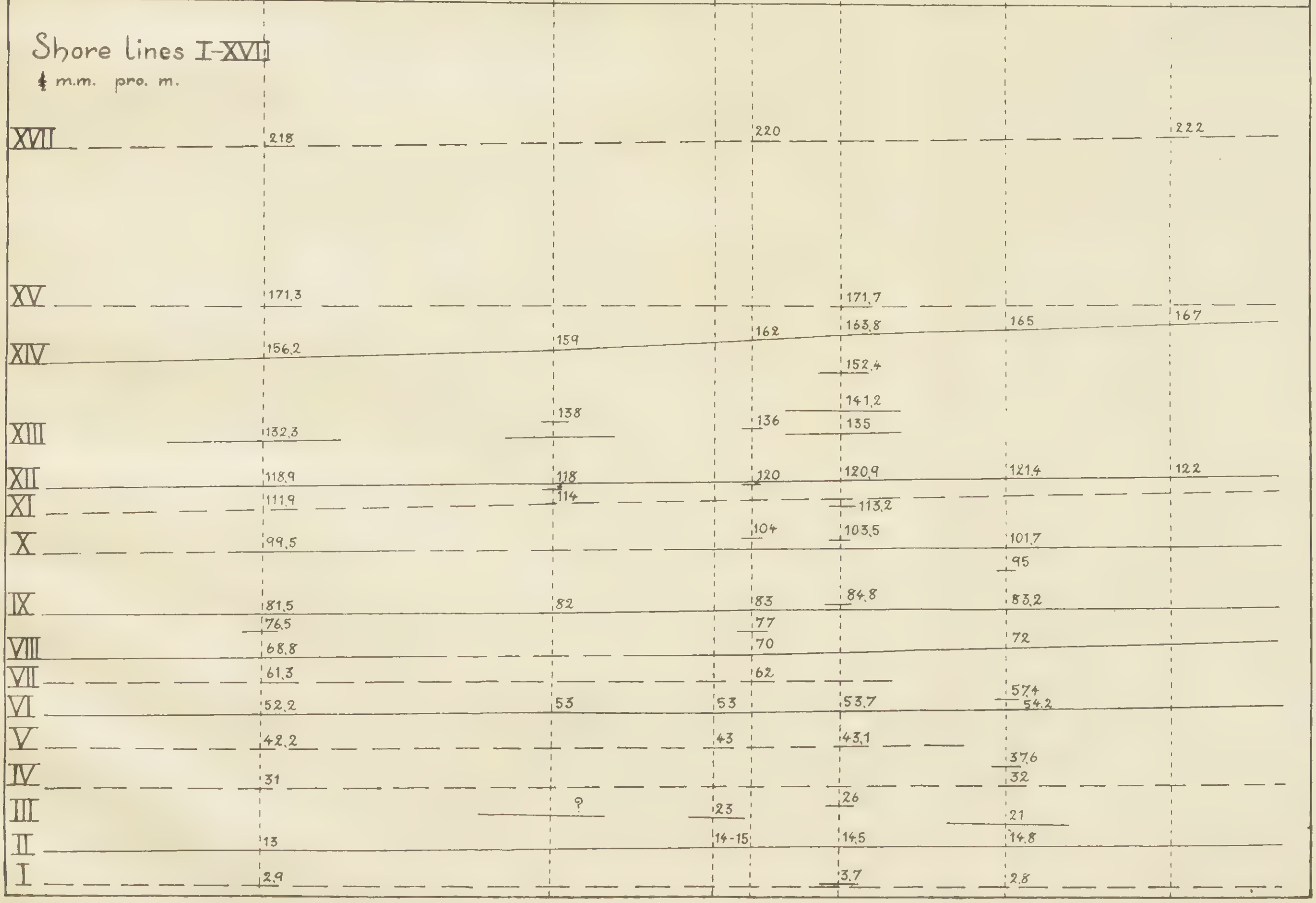

Weber Ridge
C. Borisoff
P. Krouglovsky
RÆKVED BAY
SOL BAY
35
31
40
61
73
87
123
130
OUTE
VAR
23°30'E
130
129
135
140
C. Shantz
P. Makaroff
86
30
21
14
9
NEMAK BAY
Gerassimov Ridge
Pavloff Plateau
Shore lines I-XVII
¼ m.m. pro. m.
XVII 218
XV 171,3
XIV 156,2
XIII 132,3
XII 118,9
XI 111,9
X 99,5
IX 81,5
76,5
VIII 68,8
VII 61,3
VI 52,2
V 42,2
IV 31
III
II 13
I 2,9



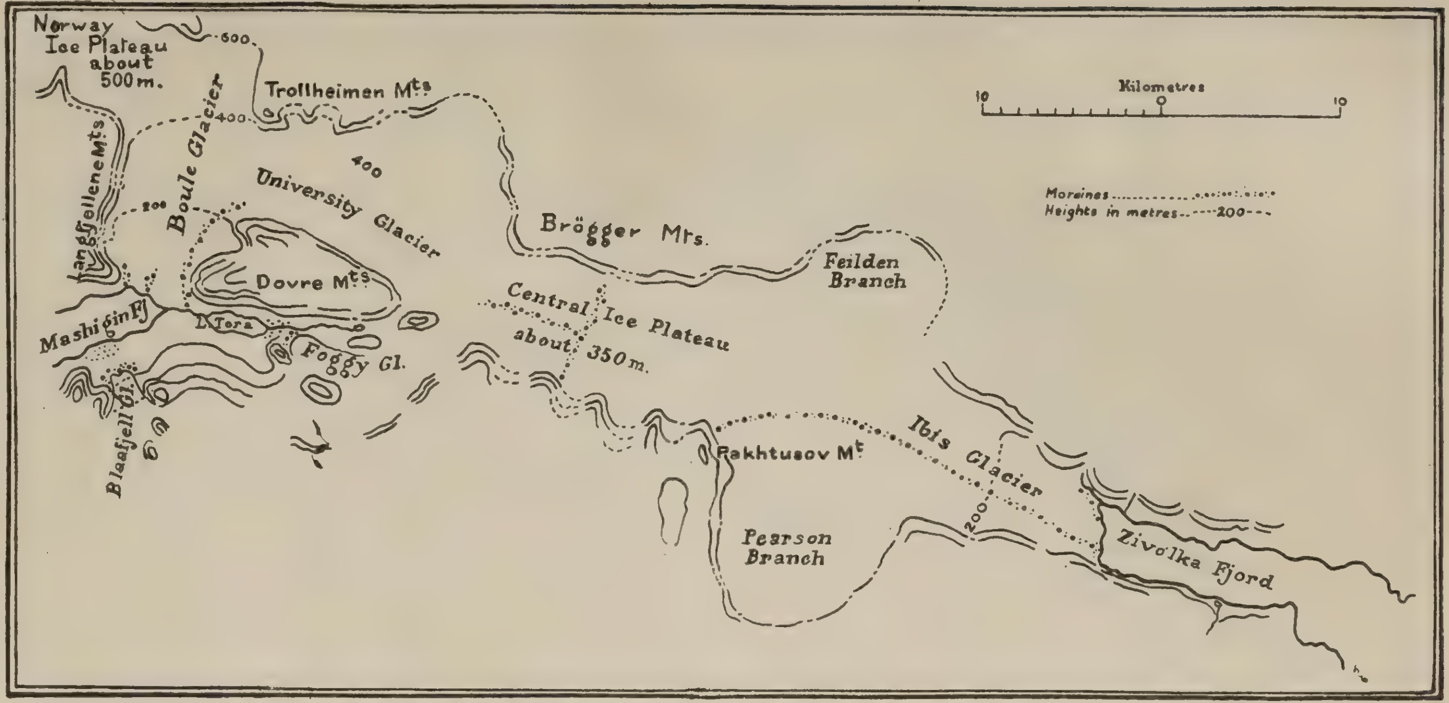
MASHIGIN FJORD
NOVAYA ZEMLYA
AFTER
B. DIETRICHSON, ENG.

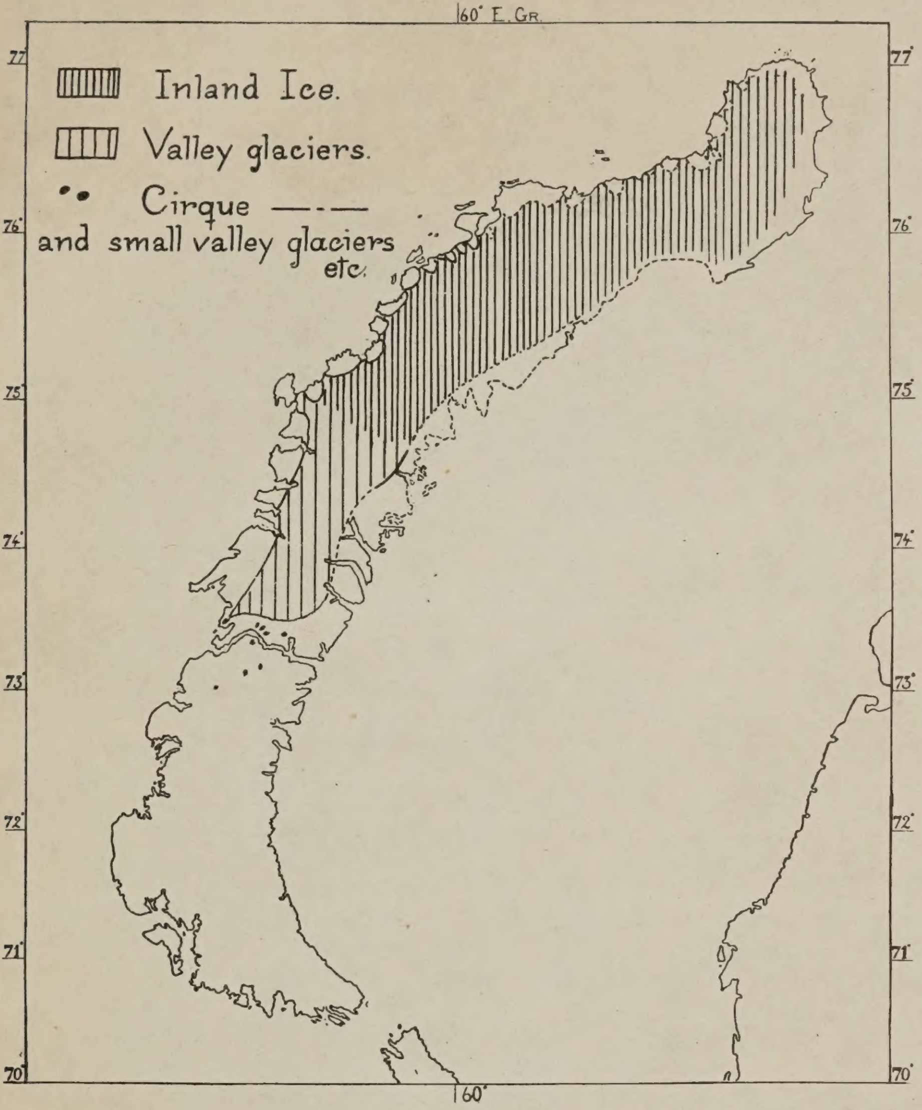
1:200 000

O.T.Gr.



Shore lines I–XVII
¼ m.m. pro. m.


Norway Ice Plateau about 500 m.
500
Trollheimen Mts
400
Langfjellene Mts
Boule Glacier
400
200
University Glacier
Dovre Mts
Brögger Mts.
Feilden Branch
Mashigin Fj.
L. Tora
Foggy Gl.
Blaafjell Gl.
Central Ice Plateau about 350 m.
Pakhtusov Mt
Ibis Glacier
200
Pearson Branch
Zivolka Fjord
Kilometres
10
0
10
Moraines
Heights in metres 200


60° E. Gr.
Inland Ice.
Valley glaciers.
Cirque
and small valley glaciers
etc.
77°
76°
75°
74°
73°
72°
71°
70°
60°

3 0112 106161679